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The Genetic Aspect of Consonance and Dissonance

By

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CHAPTER I

Introduction

It is perhaps more true of music than of any other art that the critics of one generation are the laughing stock of the next. The question of acceptable harmonic progressions has been a bone of contention between composer and listener from everlasting to everlasting. It matters not with what period of musical history we concern ourselves, there is always evidence that the great composers were being continually taken to task on the ground of impossible harmony. Even Mozart was attacked by Hans Georg Nägeli[1] for certain progressions in his "Jupiter" symphony; Beethoven became notorious for outraging the tender feelings of theorists of his day; fifty years later Wagner was struggling to persuade the world to endure harmonies which were to become shortly afterwards a chief resource for popular nights at the symphony. In our own time Strauss set out by appalling his hearers with a "wild experimentation" which a London critic described as "discordant for the mere sake of discord";[2] one by one he has converted his opponents until, as Newman says,[3] "Any one who now thinks Tod und Verklärung a tough nut to crack is looked upon as a hopeless conservative." But the end is not yet. More recently Sibelius has given concert-goers a start with his Symphony Number 4, of which W. J. Henderson writes: "He has swallowed the disjointed sequences, the chord of the minor second, and all the Chinese horrors of the forbidden fifths." Another critic remarks, "It is as inconsequential as the ravings of a drunken man." Doubtless the critics of Sibelius will be making their apologies ten years hence.

What is the ultimate meaning of all this? For the answer to this question, practical music will have to turn to theory, and

[1] Jahn, Life of Mozart, III, 34.
[2] Newman, Musical Studies, 290.
[3] Op. cit., 291.

especially to the theory of consonance. How far an answer may be expected from this quarter we shall see at the conclusion of the present discussion. But, first, we shall be obliged to review and, to a certain extent, to revise the theoretical situation.

CHAPTER II

Theories of Consonance

The problem of consonance is one that may be attacked from the various standpoints of mathematics, of psychology, and of physiology. The last-mentioned branch of consonance theory may, however, be eliminated from consideration here, since the little that it has at present to offer is of very questionable validity. Of the other two, it was the mathematical aspect that most concerned theorists from the time of Pythagoras to that of Helmholtz, whereas during the last fifty years attention has been given increasingly to the psychological aspect.

The mathematical standpoint is best represented by the philosophers Descartes, Leibnitz, and more especially Euler,[4] all of whom were impressed in true Pythagorean fashion by the general significance of number relations. The fact of greatest moment to them was the correspondence betwen the physical datum of greater or less simplicity in vibration ratios and the conscious experience of greater or less consonance. Thus for the 1:2 ratio we have the very consonant octave; for the 2:3 ratio the less consonant fifth; for the 4:5 the imperfect consonance of the major third; and so on to the harshest dissonances. According to Euler the human mind perceives the commensurability of pitch numbers as such, and derives pleasure from discovering the law of their arrangement.

These correspondences between the physical and the conscious are unquestionably facts of fundamental importance, but they leave the conscious phenomena themselves no better understood than before. Further progress in the minute observation of the mental facts was inhibited in these investigators by their strong bias for the delights of "arithmetical mysticism," as Helmholtz expressed it.[5] Such a psychology as they worked out was merely mathematics with a new name. The changed

[4] Helmholtz, Sensations of Tone, Ellis' translation, 229 ff.

[5] Sensations of Tone, 229.

standpoint of the present day is voiced by Professor Max Meyer when he says,[6] "Neither the physicist nor the physiologist can prove by physical or physiological laws why we must enjoy certain combinations of tones. It is the psychologist's task to determine the asethetic laws which describe the subjective as well as the objective conditions of aesthetic enjoyment."

But when we have claimed that consonance is essentially a problem for psychology, we have not yet limited its method of treatment. As psychologists we must, of course, regard our given conscious phenomena as so many facts to be described in detail and related to each other wherever possible. But this may be done with only a minimum of reference to the past or the future. We may simply characterize present facts in terms of other present facts. On the other hand, our prevailing interest may cause us to regard our subject-matter as merely a phase in a course of development. We may seek to clarify existing conscious phenomena by reference to their probable mode of genesis. The importance of the latter method as complementary to the first is fully recognized in general psychology, but the literature on the subject of consonance betrays as yet a rather marked bias for the first. Any given experience of consonance is usually taken for granted, as given once for all, and the nature of its ancestry is too little considered as a possible source of new light. This one-sided viewpoint will become apparent as we examine briefly the four leading psychological theories of consonance, those of Helmholtz, of Lipps, of Krueger, and of Stumpf.

Helmholtz

The present-day psychology of consonance and dissonance begins practically with Helmholtz. The views set forth in his "Tonempfindungen," while by no means new at every point, represent the first thorough-going effort to embrace all the facts under a consistent theory. So tenaciously has this theory held on that in spite of repeated attacks from a very considerable num-

[6] M. Meyer, Contributions to a Psychological Theory of Music. Missouri University Studies, 1901.

ber of critics, such as Oettingen, Mach, Riemann, Engel, Melde, Lipps and Stumpf, it is even to-day the popularly understood explanation of consonance and dissonance. But Stumpf gave it, for the large majority of theorists at least, the final *coup de grâce* in the first chapter of his "Konsonanz und Dissonanz."[7] Suffice it here to give a brief statement of Helmholtz's position, and a summary of the objections which have seemed to make necessary its abandonment.

The psychological principles invoked by Helmholtz,[8] in explaining the difference between consonance and dissonance, were two: similarity and sensory roughness. Consonances are characterized positively by the similarity of two tones due to their possession of identical overtones, and negatively by the absence of perceptible beats. Dissonances are characterized positively by their rough sensory quality due to the beating overtones of the two clangs, and negatively by a dissimilarity due to the lack of identical overtones. This theory has the great advantage of simplicity in that it finds its criteria in fairly obvious characteristics of the sensations themselves, and not in some more obscure processes supposed to be aroused by the sensations. But its critics have raised well-nigh unanswerable objections at every point.[9] To the statement that dissonance is due to beating overtones, it is answered:

1. That dissonance can be produced without beats, as when two simple tones of 700 and 1000 vibrations are sounded together. Here there are no overtones, and the fundamentals give 300 beats, which is above the Helmholtzian limit of perceptibility, i.e., 132. By putting together a number of such intervals, it is possible to form chords as free of beats as the most consonant chord in music, and yet more dissonant than the most extreme discord.[10]

2. That dissonance continues to be perceived as such when two tuning forks are placed, one at one ear another at the other,

[7] Akustik und Musik, I, 1-19.
[8] Sensations of Tone, 182-228.
[9] Stumpf, Musik und Akustik, I, 1-19.
[10] Stumpf, op. cit., 7, 8.

and both sounded too weakly for beats to be produced. The same is true of the cases of double hearing, where one ear hears a tone slightly higher than the other. Beats are out of the question here, but the dissonance is sometimes most painful.

3. That the greater awareness of beats in the lower region of the scale should mean a change in consonance corresponding to pitch changes. Such is not the case.

4. That the consonance of an interval might be expected to vary according to the timbre of the instrument, since different timbres mean different overtone relations. But this again is demonstrably not the case.

5. That in experiments on mistuning intervals made by pure tones, it has been found that a variation of four vibrations could be detected. This could not conceivably be true if judgments of purity were made possible only by characteristic overtone effects.

To the proposition that consonance is determined by the similarity between the two clangs, due to their possession of identical overtones, the answer is made that this cannot apply to simultaneous clangs, because the only possible effect of two identical overtones in such a case is that of mutual reënforcement.[11, 12] When the same overtone occurs in two clangs, sounded simultaneously, what will appear to the ear is simply one relatively loud overtone in the total sound complex. The Helmholtz theory, accordingly, makes it necessary to limit the explanation of consonance to successive notes; in short, it involves a transfer of the meaning of consonance, making it identical with melodic relationship. Meyer, who has given more attention to melody than any other experimenter, makes a sharp distinction between melodic relationship, which has to do only with successive tones, and consonance, which has to do only with simultaneous tones.[13] He shows in detail, for example, how Wagner's interest in a variety of melodic relationships was often at variance with the usual requirements of consonance. Melody is clearly seen to be

[11] Stumpf, op. cit., 15-19.

[12] Krueger, Differenztöne und Konsonanz, Archiv für die Ges. Psych. I, 214-216.

[13] Contributions to a Psychological Theory of Music.

one kind of ultimate relation, consonance another, and the one is not to be explained by the other.

Thus neither the identity of overtones nor the roughness of beats between overtones prove to be adequate criteria of consonance, and with their failure the Helmholtz theory falls to the ground, leaving the problem to be solved by his critics.

Lipps

Lipps, whom we may mention next after Helmholtz, sets out from a single principle.[14] Consonance, according to his theory, rests on the rhythmic accord of unconscious excitations. Stated more in detail, his explanation is as follows. Each single physical vibration causes a separate unconscious process which Lipps describes as micro-psychic. This micro-psychic process is the imaginary middle term between the physical stimulus and the conscious effect. There is a one to one correspondence between the physical stimuli and the micro-psychic processes, but any number of the latter may fuse into an uniform conscious experience. Given two tones of 200 and 100 vibrations respectively, we obtain two series of unconscious experiences, one of 200 separate excitations, the other of 100. Now since 2 : 1 is a simple rhythmic form, we have a micro-rhythmic experience of a simple and therefore pleasant sort, fusing into the conscious effect of the octave consonance. If micro-psychic processes are excited in such a way that every third member of one series corresponds with every second of the other, we get a less simple micro-rhythm and a less consonant effect in consciousness,—the fifth. Beyond a certain point of complexity the rhythm appears in consciousness as the characteristically unpleasant effect of dissonance.

It is obvious at once that the "psychic" effects with which Lipps deals are not given in any state of awareness, but must be deduced from the conscious effects they are intended to explain. This is an instance of the "explanation" of the conscious by the subconscious, an explanation which, as Professor Münsterberg has shown, amounts to nothing more than an ac-

[14] Grundtatsachen des Seelenlebens, Ch. XI.

ceptance of the problem itself as its own solution.[15, 16] Such a method of procedure is so far removed from laboratory experiment that it seems to mark a retrogression from Helmholtz back to the speculative vagueness of his predecessors, and for this reason it has met with rather caustic treatment at the hands of those for whom psychology ceases to be scientific when it ceases to be empirical. As psychologists we are permitted to describe only the facts; hence, when Lipps goes beyond the realm of psychic experience to one of unconscious, unverifiable facts, his position is interpreted as a capitulation on the part of psychology. Meyer, for example, speaks of the Lippsian law of tone relationship as "linguistically derived" from a "pseudo-experience of micro-rhythm."[17]

More specific are the criticisms of Stumpf and Krueger, who meet Lipps on his own ground with a view to proving his deductions at fault. As against the Lippsian assumption that the tone sensation c′, corresponding to 256 vibrations, is due to the fusion of 256 separate unconscious waves, Krueger points out[18] that the stopping of a number of holes in a siren does not alter its characteristic quality of tone; in other words, that irregular interruptions of the physical succession of vibrations are without effect on the singleness of quality of the tone as consciously experienced. And even granting the reality of unconscious rhythm, it may be urged that the 5 : 6 ratio of the minor third and the 5 : 8 of the minor sixth make very good consonance, but very bad rhythm as we ordinarily think of the latter. More difficult still is the situation when we pass from intervals to chords.[19] The 4 : 5 : 6 ratio of the major triad, considered as rhythm, would be so confused that it might as well be 7 : 8 : 9. And there is the further objection, stressed by Stumpf[20] that

[15] H. Münsterberg, Psychotherapy, Ch. VI.

[16] H. Münsterberg, in Subconscious Phenomena, I.

[17] M. Meyer, Unscientific Methods in Musical Esthetics, Journal of Philos, Psych. and Scientific Methods, 1904, I, 707-715.

[18] Kreuger, Differenztöne und Konsonanz I, 218, Archiv für die Ges. Psych. I.

[19] Krueger, op. cit., 220.

[20] Stumpf, Konsonanz und Dissonanz, 28 ff.

no matter how simple the tonal ratio, yet, owing to differences of phase, we hardly ever have physical coincidence of vibrations. These differences of phase are without effect on the consonance of the interval, but they would completely alter the character of the rhythm.

In order to meet such objections Lipps, after having assumed a whole realm of unconscious micro-rhythms, is obliged to assume further that there are possibilities in it which do not exist in the realm of conscious rhythm.[21] By the time micro-rhythm has been specially adjusted to meet all these requirements it remains with little more psychological significance than Euler's "unconscious recognition of number relations" proposed nearly two centuries ago.

KRUEGER

The theory of Krueger, which we may next consider, although in point of time it actually followed that of Stumpf, is a return to the more scientific method of Helmholtz, in that he attempts to refer consonance and dissonance to simple psychic facts verifiable by experiment.[22] But whereas Helmholtz emphasized largely the effects of overtones, Krueger attaches the greatest importance to difference tones.[23] He sets out with the general statement, deduced from his experiments, that the five difference tones of two simultaneous tones are to be calculated by always subtracting the two remaining smallest vibration numbers.[24] Thus for the ratio 1 : 2 the only possible difference tone would be 1, which would coincide with the lower generator; for the ratio 4 : 5 the difference tones would be 1, 3, 2, 1, 1, of which three fall together. An examination of each particular case of consonance and dissonance shows that not only do all the dissonant intervals contain difference tones which beat, but each one contains, as a result of the closeness of its difference tones, at least one mistuned unison,—that is, two tones lying so near

[21] Tonverwandtschaft und Tonverschmelzung, Zeitsch. für Psych. XIX, 1-40.
[22] Differenztöne und Konsonanz, Archiv für die Ges. Psych. I, 254 ff.
[23] Krueger, op. cit. 255 ff. and II, 1-80.
[24] Op. cit., I, 270.

together that they cannot be distinguished as two, but give an intermediate tone of a peculiar blurred character.[25] Consonances, on the other hand, are without exception free from difference tone beats, and contain only pure unisons, since the difference tones either fall exactly together or at least the distance of a third apart. The psychic effect of this physical difference is the clarity of the consonances as contrasted with the blurred and heterogeneous quality of the dissonances. A further significant physical difference is that the number of separate difference tones in the consonance is comparatively small, because of the five at least two fall together. On this account the consonances approximate the effect of unison more nearly than the dissonances.[26] Since the unison is the earliest and most familiar tonal experience of the ear, an approximation to this appears as the psychic effect of familiarity, an effect which is enhanced by the fact that the consonance itself is more frequently heard than the dissonance, and is therefore more familiar on its own account.[27] Taken together, all the characteristic relations of difference tones to consonant and dissonant intervals bring it about that the consonances are relatively clear, simple, and familiar; the dissonances are blurred, complex and strange.

This theory has found an uncompromising critic in Stumpf. The position taken by him in his first article, entitled "Differenz-Töne und Konsonanz,"[28] is one from which he has receded but little in all the controversy which has followed. [29, 30] He begins by raising the question of fact as to the relation of difference tones stated by Krueger. Passing that by, he argues that even if Krueger's findings be admitted, they still fail to provide an adequate criterion of consonance and dissonance as we distinguish them in musical experience. Krueger's physical test of a perfect consonance is, as we have seen, the absence of beats and of

[25] Op. cit., II, 15.
[26] Op. cit., II, 38.
[27] Op. cit., II, 42.
[28] Stumpf, Zeitschrift für Psych. 1905, Vol. 39, 269-283.
[29] Krueger, Psych. Studien, I, II, IV, V.
[30] Stumpf, Zeitschrift für Psych. Vols. 55, 59.

intermediate tones among its difference tones. But Stumpf[31] calls attention to the fact that the interval 8:11, an extreme dissonance, gives the difference tones 3, 5, 2, 1, 1. The smallest interval here is a fifth, hence there can be no difference tone beats or intermediate tones. It should therefore be a perfect consonance! Stumpf[32] cites a large number of more or less dissonant intervals, such as 11:15, 13:18, 12:17, 7:10, in all of which the smallest difference tone interval is a major third. All should, therefore be consonances, but not one of them is heard as such. He shows further the possibility of constructing triads which contain no difference tone beats, but yet are dissonant in every interval. Such, for example, 3:7:10; 7:10:17; 10:17:27. And, lastly, it is possible to rule out difference tones altogether by sounding two tuning forks very softly one in one ear, the other in the other, but this makes absolutely no difference as to the consonance of the interval.[33]

Not only does the elimination of the effects described by Krueger fail to alter the characteristic quality of a dissonance, but the artificial production of corresponding effects in a consonance does not alter its consonance. Stumpf points out that if we play the triad c-e-g, and play in addition to it low beating tones in the base, the triad keeps its characteristic quality.[34] The properties of the lower part of the tone complex do not go over into those of the upper part. Exactly the same is true of the colliding overtones on a piano, which do not make a given triad less consonant. In short, the criteria of consonance must be peculiar to the tones as such, and not due to any external feature superadded to them.

Stumpf

There remains Stumpf's own theory, which at present enjoys a wider recognition than any other. As against Lipps, he maintains that the criterion of consonance must be sought in conscious

[31] Stumpf, Differenz-Töne und Konsonanz, Zeitsch. f. Psych. 39, 273.
[32] Op. cit., 273.
[33] Op. cit., 274 ff.
[34] Op. cit., 278 ff.

experience; as against Helmholtz and Krueger, that it must be a quality inherent in the tones themselves. After eliminating all other possible psychical conditions, he concludes that the ultimate psychological factor is to be found in the fusion of simultaneous tones; that is, in the relation of two sensory contents by which they form not a mere sum but a unit.[35, 36] The general law is, briefly, the greater the fusion the more perfect the consonance.

Fusion, according to Stumpf, is something quite distinct from unanalysability. In fact, the fusion of a given interval is distinctly present as such to consciousness only after analysis has taken place. It is the qualitative unity that persists in a chord after its real unity, *i.e.,* its indistinguishability, has given way to an awareness of separate intervals.[37] This residual qualitative unity, says Stumpf, is an original relation, just as a sensation of color, only to be learned by examples, and not to be referred to anything more ultimate psychologically.

The validity of Stumpf's psychological position depends, as Krueger has shown,[38] in a large measure on his ability to maintain clearly the difficult distinction between the unity which disappears with analysis and the unity which remains after analysis. Here is a difficulty of which he has acquitted himself only imperfectly, and sometimes not at all. His experimental demonstration of the various fusion degrees is made according to difficulty of analysis.[39, 40] Stumpf justifies this by saying that, other things being equal, a low degree of fusion will actually mean greater ease of analysis. His tests were made with unmusical persons whose powers of analysis would naturally be comparatively low. He found that the likelihood of their judging an interval to be a single note was greatest in the case of an octave; next in order came the fifth, fourth, thirds, sixths and

[35] Tonpsychologie, II, 127 ff.
[36] Konsonanz und Dissonanz, Akustik und Musik, I, 34 ff.
[37] Konsonanz und Dissonanz, 43 ff.
[38] Archiv für die Ges. Psych. I, 236, Differenztöne und Konsonanz.
[39] Tonpsychologie, II, 142 ff.
[40] Konsonanz und Dissonanz, 36, 37.

sevenths.[41, 42] He argues that the particular difficulty of analysis experienced in these cases cannot be due to beats or overtones, since the results are the same when pure tones are used; it cannot be due to absolute distance, since the largest of the intervals, the octave, presents the greatest difficulty; it cannot be due to feeling value, since the greatest feeling accompanies hearing the thirds and sixths which lie in the middle of the series; and it cannot be due to practice, since the persons are unpracticed in music. Therefore, it must be the qualitative unity, or fusion, that makes distinguishability less in the case of the octave and more in the case of the seventh.

Manifestly Stumpf does not get beyond unanalysability as the experimental fact. Fusion, which is assumed to be distinct from difficulty of analysis, is after all arrived at only by a process of eliminating other possible factors in a given case of difficult analysis. The Stumpfian dilemma, as his critics see it, is that whenever he sharply separates fusion from difficulty of analysis, what remains is not a clearly understood psychological principle, but only a new name for the different degrees of harmony.[43] Nevertheless, in spite of considerable disagreement among various authors as to the exact meaning of tonal fusion, it is quite generally agreed that Stumpf has pointed the way to proper treatment of the problem.

It is not the purpose of this discussion to argue specifically for or against any of the consonance theories just mentioned. They all have their spokesmen who are contributing abundantly to the controversial literature of psychology. My own contention will be that all of them have, by giving too slight attention to the genetic aspect of the problem, left an inadequate account of certain facts which sooner or later must be explained. A complete theoretical account of consonance will have to reconcile the sharp sensory distinction between a consonant and a dissonant quality with the fact that the dividing line between consonance and dissonance has shifted in the last thousand years.

[41] Tonpsychologie II, 145-179.
[42] Konsonanz und Dissonanz, 36, 37.
[43] Krueger, Op. cit., II, 235, 236.

If we examine Krueger's theory in this connection we see that he provides adequately for a fundamental breach between consonance and dissonance, but it is something given once for all. If all consonances are free from difference tone beats, while all dissonances contain them, we have indeed the basis for a sharp qualitative distinction, but it is one which would seem to preclude the possibility of change. Krueger does, to be sure, mention the fact that our more frequent hearing of an interval makes it more familiar,[44] but this is merely incidental to the fundamental criterion above mentioned.

Stumpf has had much to say about the genesis of music,[45, 46] but concerning the genesis of consonance his position is not unambiguous. In his *Tonpsychologie,* II, 208 ff., he takes up the question whether frequent combination is the cause of fusion. This question he answers in the negative as far as the possibility of psychic combination is concerned. But what is denied as a psychic possibility is, a few pages later, affirmed as a physiological possibility.[47] The physiological basis of fusion, he says,[48] is the specific synergy of the cortex, that is, "a determinate mode of coöperation of two nervous structures, having its ground in the structure of the brain, of such a kind that whenever the two structures give rise to their corresponding sensations there arises at the same time a determinate degree of fusion of these sensations." And on page 215 he makes the suggestion that "the mechanism of synergy, connate with the individual, may have been acquired in the course of generations, and perhaps the influences under which it took shape may have been in part mental influences. Impressions that affect the sense organ, together with relative frequency, might gradually set up a disposition to conscious fusion." He even goes further and ventures a few "vague conjectures," to use his language, as to how some of the early intervals were established. At this time he

[44] Op. cit., II, 42.

[45] Stumpf, Geschichte des Consonanzbegriffes; Abhandlungen der Bayerischen Akad. der Wissenschaften, Vol. XXI, 1901.

[46] Stumpf, Die Anfänge der Musik.

[47] Tonpsychologie, II, 211, ff.

[48] Ibid., 214.

evidently admitted the probability that the fusion grades had been partly developed since the advent of the human race. He has, however, since modified this position, and in *Die Anfänge der Musik,* page 84, he makes the following statement: "In der Tonpsychologie legte ich die Meinung zugrunde, dasz in den Uranfängen des Menschengeschlechts die Verschmelzungsunterschiede doch noch nicht vollständig ausgebildet gewesen seien, was ich jetzt nicht mehr fur wahrscheinlich halte. Die Untersuchung der Sinnesempfindungen bei den heutigen Naturvölkern hat immer mehr gezeigt, dasz wesentliche Unterschiede gegenüber den unsrigen nicht vorhanden sind." And in the same book, page 27, he says of the original character of the fusion grades: "Diese Einheitlichkeit des Zusammenklanges ist . . . nicht eine Folge der musikalischen Entwickelung, sondern eine durch die Natur der Töne oder der ihnen zugrundeliegenden Gehirnprozesse notwendig bedingte Erscheinung." He proceeds here to suggest the probability that the octave is as consonant for animals as for us, the only difference being that they do not attend to its consonance relation as such. Two more statements will serve to make clear his present position as regards the evolution of consonance. In *Akustik und Musik,* Vol. I, p. 32, we read: "Es scheint eine Verschiebung des Lustgefühls von der vollkommensten Konsonanz gegen die unvollkommen hin stattzufinden, aber eine Verschiebung der Konsonanzverhältnisse selbst findet nicht statt." And, lastly, in his article entitled *Konsonanz und Konkordanz,*[49] "Konsonanz und Dissonanz sind nur graduell verschieden, und es kann der Grenzstrich an verschiedenen Punkten der Reihe gelegt werden, wie er denn tatsächlich von den alten schon nach der Quarte gezogen wurde, wahrend wir ihn nach der Terzen und Sextengruppen setzen und spätere Musiksysteme ihn vielleicht nach den Siebernen setzen werden." Taken together, the above statements indicate that the genetic problem of consonance that now exists for Stumpf is limited to the changing feeling attitudes toward the various intervals. The change of an interval from dissonance to consonance signifies for him nothing more than our growth in power to conceive an interval differently in a developing

[49] Zeitschrift für Psychologie, Vol. 58, p. 341.

system of harmony. As to the actual degree of consonance or fusion of a given interval, that is something which has not changed since the beginning of the race. Such change as took place before then is to be accounted for in purely physiological terms; the influence of external stimuli is apparently of little account.

This negative attitude of Stumpf on the genesis of consonance seems to have been generally accepted without protest. The only article I have been able to find in which the opposite position is definitely stated is that of Professor R. M. Ogden.[50] He admits that Stumpf's arguments against the possibility of "inseparable associations"[51] are irrefutable, provided we regard the phenomena of consonance to be the result of an individual's tonal experience during his own lifetime, but thinks that "we have every reason for supposing that congenital associations result from racial experience of a definite and oft recurring sort, to produce instinctive modes of adjustment and attendant complexes of experience which are fundamentally unified." The last statement is in full agreement with the position to be defended here, but I disagree as to the irrefutability of Stumpf's arguments against the formation by the individual of "inseparable associations."

In the first place, a consonance, conceived as an association, does not possess the degree of inseparability which Stumpf assumed to be necessary in his *Tonpsychologie*. The interval c-a♭ is quite consonant so long as we imagine ourselves in the key of A flat. But imagine the same interval to be c-g♯ and it at once takes on a character of decided dissonance. Stumpf has given what seems to be the proper explanation of this fact;[52] to be sure, not the same explanation which he had given previously in *Akustik und Musik*,[53] but this point does not concern us here. The important fact is that if we conceive the imperfectly consonant minor sixth as an association, it is an association easily

[50] R. M. Ogden, A Contribution to the Theory of Tonal Consonance, in Psych. Bull. VI, 297-303.

[51] Ibid., 299.

[52] Konsonanz und Konkordanz, 334, 335.

[53] Akustik und Musik, Vol. I, 104 ff.

altered according to the musical context. In fact, musical disorientation easily affects our whole system of tonal relations if we are introduced for a time into a realm of amusical tone-steps. The usual acoustical perspective can by such a process be so altered that even the octave may appear equal to the higher fifth.[54]

But waiving the question as to how inseparable is the fusion of a consonant interval we may recall that certain observed facts, notably those of synaesthesia, favor strongly the view that relatively inseparable associations can, under certain conditions, be formed by an individual, especially during childhood. C. S. Myers[55] points out that in all his cases of colored audition it is the *individual* experience which seems to determine just what particular color will be associated with a given tone. A tone that is "seen" by one subject as green, appears to another as blue, and to another as yellow. "Two members of the same family, both endowed with synaesthesia, will hotly dispute the colors of certain words or vowels." Myers sees no possible explanation of these individual variations otherwise than as accidental personal associations. That this sort of association may be formed relatively late is indicated by the fact one subject reported on by Myers[56] acquired, by playing with figures at the age of twelve, the rather troublesome habit of seeing with every letter of the alphabet its individual number. This association, acquired at random, has persisted for eighteen years, although it is not invariably present. Myers thinks that the general setting in which such connections are found must be a strong tendency to a certain kind of association,—"a 'sympathy,' the psychological and physiological basis of which is unknown to us." It seems to me that in any consonance theory some such 'sympathy' as this must be assumed as the basis of the greater affinity of the simpler related tones, but this does not prejudice the possibility that the actual realization of definite fusion developments may take place during the lifetime of an individual. Certainly the cases of

[54] L. E. Emerson, The Feeling Value of Unmusical Intervals, Harvard Psych. Studies, II, 269, 270.

[55] C. S. Myers, A. Case of Synaesthesia, Brit. Journ. Psych. 1911, IV, 228-238.

[56] Ibid., 238.

Myers leave little doubt that synaesthesia, at least, though in general a congenital endowment, may in its particular manifestations be the result of the individual's life experience. To be sure, the "associations" in these are sensory rather than ideational. But exactly the same is to be said of that peculiar association of two tones which causes them to be heard as relatively unified.

Stumpf argues[57] that if mere being in consciousness innumerable times necessarily involved fusion, the person who heard music frequently should be less capable of differentiating the two notes of an octave than one who heard music seldom. But "fusion," according to his own definition, is something distinct from analysability; it is a qualitative unity that persists unaltered even after the ear has discriminated the two elements involved. If Stumpf maintained his own definition with strict consistency he would have to admit that the very practice which improves the musician's ear in discriminating the two component tones of an interval may be at the same time fusing the same two tones into a more perfect qualitative unity. It is only his failure to make clear the psychological difference between the two kinds of unity —the numerical "Einsheit" which disappears with analysis, and the qualitative "Einheit" which remains after analysis—that enables him to argue, now as if fusion were identical with difficulty of analysis, now as if it were something altogether distinct.

The view to be maintained by the writer, that a tonal fusion means simply a highly permanent connection wrought under the direct influence of repeated sensory co-incidences, is rejected by Stumpf largely on "a priori" grounds; there is no record that this possibility was ever put by him to experimental test. The experiments to be reported in this paper were devised with the view to examining the characteristic changes effected by the frequent or prolonged hearing of certain intervals, it being my hope that an interpretation of these changes might throw light on the possibility of fusion changes denied by Stumpf. But before passing to the experimental results I shall state my own theoretical position more fully.

[57] Tonpsychologie, II, 210.

CHAPTER III

A Genetic Theory

I shall begin with an hypothetical account of the genesis of consonance, the theoretical soundness of which will be tentatively assumed. After an examination of the historical and experimental facts to which it offers an explanation, I shall return to a discussion of theoretical points in detail. The tentative hypotheses with which we shall begin are:

(1) Consonance and dissonance have to do directly with the degree to which an individual is able to synthesize[A] two tonal elements into a unified complex; this synthesis is unaffected by analysis, and the individual's ability to analyse is unaffected by synthesis.

(2) Tonal synthesis may be conceived as an undertaking, attended by success or failure on the part of the hearing organism. Success is experienced as the characteristic quality of consonance, failure as that of dissonance.

(3) The inherent feeling value of a particular interval is a function of two factors—success and degree of difficulty. It is the barely successful synthesis, in which the individual accomplishes with difficulty the unification of a manifold, that he finds the keenest pleasure. If the synthesis is effected without effort he has little awareness of his accomplishment, and therefore little pleasure. If, on the other hand, in spite of his synthesizing activity, he is baffled by the complexity of the manifold to be unified, he experiences acute displeasure.

(4) A certain initial disposition to synthesis is pre-determined for a given interval by the simplicity of its numerical ratio. That is to say, we must pre-suppose a "sympathy" such as that which Myers postulates in the case of synaesthesia,—a more or

A. I shall use the expression "synthesis" instead of "fusion" in order to avoid the ambiguity which has come to attach to the latter term. By "synthesis" I mean simply a kind of fusion that is wholly independent of analysability.

less strong tendency to association, the strength of the tendency being proportionate to the simplicity of the ratio.

(5) The actual degree to which any given interval realizes its possibilities of synthesis depends upon the number of times the interval has been attentively heard by an individual or by his ancestors.[A]

(6) Between the distinct qualities of consonance and dissonance lies an intermediate zone of neutrality such as, for the present-day ear, 4:7 relation. In such cases neither success nor failure of synthesis is pronounced. It is characteristic of this zone that change due to frequency of hearing is more marked than for either the decided consonances or dissonances. Also we are likely to find the greatest individual differences in judgment of an interval when it has reached this stage.

Our task will be to show that the above assumptions, taken together, are the ones which best satisfy the facts. . Now the facts with which we are concerned are of two kinds, those derived from the actual development of musical feeling, and those derived from experiments designed to test the conditions of consonance. We may examine the two kinds in order.

A. The addition of the phrase "or by his ancestors" may seem to imply an anti-Weissman point of view on the question of acquired characteristics. I should be unwilling to admit, in the present state of that controversy, that such an implication would necessarily invalidate my position, but I do think it possible to account for the transmission, here assumed, as a purely social one. If thirds are acquired as a consonance by one generation they will be heard so much the more by the next, and will therefore become more completely consonant. We may accordingly interpret the degree of synthesis of a given interval either in Lamarckian fashion, as being in part a congenital association resulting from race experience, or, in accordance with Weissmannian principles, as resulting entirely from an individual experience which has had the benefit of the accumulations of the race. I am indebted to Professor B. M. Anderson for the suggestion that such accumulation of increments of advance as is here involved may be plausibly assumed in any society where the musical profession tends to run in families. The son, on account of his father's tutoring, reaches at an earlier age the point attained by his father, the grandson surpasses the son, and so on.

CHAPTER IV

Evidence from the History of Music

Historical evidence does not go back far enough to either prove or disprove the statement that the octave was originally a dissonance. To be sure, we have what at first might be taken as evidence to the contrary in the findings of von Hornbostel and others[58] to the effect that our present-day "primitive" peoples of Africa and Asia make abundant use of parallel octaves, and in a large number of cases, even of fifths and fourths. But it hardly needs to be argued that the conditions here are far from original. Even Stumpf, who makes much of anthropological evidence as proof that the present-day fusion grades were an original possession of the race, makes the following admission:[59] "Wir müssen freilich auch schlieszen, dasz das meiste, was bei den Naturvölkern an Musik beobachtet wird, keineswegs die allerprimitivsten Zustände darstellt, sondern mindestens in Hinsicht . . . des ganzen Aufbaues doch schon vielfach eine lange Geschichte hinter sich hat." And C. S. Myers,[60] speaking of the contamination of primitive music, expresses the opinion that unpolluted aboriginal music can hardly be found nowadays owing to the almost universal influence of the trader and the missionary. He says: "We have evidence of these conditions in the influence of Arabic and Portuguese tunes introduced into Africa, and in the spread of favorite native airs throughout North America and throughout Australia."

If we examine still more rudimentary conditions we again find that such evidence as is obtainable is inconclusive. Experiments have been made[61] to see whether a bird, by hearing its melody played after it in another key, could be induced to transpose. No variation on the part of the bird could be noticed. The

[58] E. M. von Hornbostel, Zeitschrift f. Angew. Psych. III, 465-487.
[59] Die Anfänge der Musik, 48, 49.
[60] The Ethnological Study of Music, Anthropological Essays.
[61] Anfänge der Musik, 11, 12.

nearest approach to transposition is a case reported by B. Hoffman.[62] He tells of a woodpecker who began by singing his song between c^3 and a^3, but with prolonged singing gradually flatted until he was singing the same song between a^2 f^3. However, as Stumpf remarks,[63] this seems to be due to a mere weakening of muscular contraction rather than to anything like a conscious transposition. There is so far not a shred of positive evidence that a bird has any conception of tone relation regardless of a particular pitch. Hence we may hardly suppose that an octave could be felt by it as in any relation to its fundamental. Such a lack, of course, does not mean that the two notes together would necessarily give a combinational quality of dissonance; we must rather suppose that at this stage everything except the particular note being sung is a meaningless confusion. But the later course of development will, I think, make plausible the assumption that the octave was the earliest dissonance. We may, at least, without prejudice to the facts that come later, accept this inferred fact as an historical starting point.

It is obvious that the octave enjoyed an early advantage over every other possible interval in its progress toward consonance. Its simplicity of ratio 1 : 2 predetermined for it a rank second only to that of the unison 1 : 1. And two circumstances led to a speedy development of its possibilities. For one thing, whenever any sound was heard that contained as many as sixteen overtones,[64] the interval of the octave would occur among the upper partials nine times, as compared with five fifths, four fourths, three major thirds, three major sixths, two minor thirds, two minor sixths, two natural sevenths, one major second, one minor second. For another, the natural difference of register for the voice of a man and a woman is such that in attempting to give the same tone they would naturally give two tones an octave apart.[65] In the primitive activity of calling signals, when every member of a company tried to hold fast to a certain tone, this must have

[62] Anfänge der Musik, 78.
[63] Ibid., 78, 79.
[64] Stumpf, Tonpsychologie, II, 209.
[65] Ibid., 215, 216.

happened often. The natural frequency with which the octave was heard would, according to the theory here maintained, bring it about that its degree of synthesis gradually increased until it passed the threshold of consonance. It was then felt as more pleasant than the unison because this success was as yet attended by considerable difficulty.

Now we actually find that among the ancient Greeks the octave had reached this point of pleasantness. They derived an acute pleasure from the practice of magadizing, that is, of having the men and boys sing in melody together in octaves. Thus in the Aristotelian Problems[66] we find the following question asked: "Why is antiphonal singing (i.e., in octaves) more beautiful than singing in unison?" This characteristic experience of the octave was, as we shall see, set apart as essentially different from any other possible combination of two notes, but it is a question how far the Greek separation of the octave from other intervals corresponded to our division of consonance and dissonance. Indeed the question of what kind of musical consciousness to attribute to the Greeks is one that has undergone an extraordinary change of interpretation within the last fifty years. Gevaert[67] is authority for the following statement: "Il fut un temps—qui n'est pas loin—où beaucoup de savants philologues et musiciens prétendaient dénier aux Grecs tout usage de l'harmonie simultanée. Quelques-uns allient plus loin, et voulaient même leur refuser la simple connaissance des accords de deux sons. LeMémoire de notre éminent helléniste Auguste Wagener sur la Symphonie des Anciens, publié en 1861, mit a néant ces opinions erronées." But if philologists and musical scholars before 1861 went too far in what they denied to the Greeks, those of to-day are surely swinging too far in the opposite direction. The commonly accepted view now is that the Greeks classed the octave, fifth and fourth together as consonances in exactly the same way that we do to-day. The only difference, it is maintained, between their consonance-dissonance division and ours is that for them the dissonance began with the thirds and sixths, whereas we include the latter among

[66] Gevaert et Vollgraff, Les Problèmes Musicaux d'Aristote, Problem 39a.
[67] Op. cit., p. 136.

the consonances. Now if change has clearly taken place in the case of the thirds during the last 2000 years, and we shall see that there is no possibility of doubting this, there should be at least a certain presumption in favor of expecting development in the case of the fifths and fourths. Evidently the scholars since 1861 have not approached the Greek passages with this presumption in mind. It has lately been agreed to translate *συμφωνία* as "consonance"; and since the fifth and fourth are from very early times spoken of by the Greeks as *συμφωνίαι*, it is argued that they must have always been full-fledged consonances. But if one sets out by translating *συμφωνία*, not as consonance in a rigid sense, but as any interval easily available in music—including both perfect and imperfect consonances, and the milder dissonances as well—the whole literature takes on a new aspect. I think there is every warrant for this translation. Certainly the passages referred to by Stumpf in his *Geschichte des Consonanzbegriffes* bear readily the interpretation that the fifth was to the Greek approximately what the third was to the fourteenth century ear, that is to say, between the positions of the third and the minor seventh for the present-day ear. This intermediate value of the fifths and fourths would account for the comparatively late period at which a clear cut distinction between consonance and dissonance occurs. Neither in Aristotle nor in the Problems attributed to him is there any particular expression for dissonance.[68] But we do have abundant evidence that the octave was in almost every respect set apart from all other intervals. Thus we read in the *Problems* 35a,[69] *Διὰ τί ἡ διὰ πασῶν καλλίστη συμφωνία*; "Why is the octave the most beautiful *συμφωνία*?" Again, in Problem 18, *Διὰ τί ἡ διὰ πασῶν συμφωνία ἄδεται μόνη; μαγαδίζουσι γαρ ταύτην, ἄλληνδε οὐδεμίαν.* "Why is only the octave employed in singing? One magadises (i.e., sings in parallels) the octave, something which is done with no other *συμφωνία*." And in Problem 17: *Διὰ τί διά πέντε καὶ διὰ τεττάρων οὐκ ἄδουσιν ἀντίφωνα*; "Why are fifths and fourths not sung in parallels (i.e., after the fashion of the octave)?"

[68] Stumpf, Geschichte des Consonanzbegriffes, 22, 23.
[69] Gevaert et Vollgraff, op. cit., 19 ff.

And in Problem 39b there is a longer passage to the effect that the octave is the only *συμφωνία* which can be used at the beginning or end of a musical piece, since it alone procures for the mind the impression of equilibrium and stability.

These four passages leave little doubt that at the time of Aristotle, or shortly afterward, the fifth and fourth were markedly less consonant than the fifths of the ninth century or the thirds of to-day. They could not be sung in parallels, and they could not be used at the end of a piece. Moreover, they were less beautiful than the octave, whereas for us the most imperfect of the consonances is the most beautiful of them all.

There is, to be sure, some indication that parallel fifths and fourths were occasionally played on instruments. Plato (Laws, VII, p. 812) speaks of the use by the zitherist of antiphonic successions other than that of the octave. If Gevaert's[70] interpretation of this passage is right, it can only refer to the doubling of the melody in fourths and fifths. But it also seems not unlikely that players of instruments, so far as they did this, were taking a step in advance of popular practice. The following passage from the *Republic*[71] indicates a strong probability that at least some of the men who handled instruments were experiencing pleasure in effects which seemed absurd to the people at large. It reads: " 'Tis as good as a play to hear them talking of their condensed notes, as they call them; they put their ears alongside the strings like persons catching a sound from their neighbor's wall—one set of them declaring that they distinguish an intermediate note, the others insisting that the two sounds have passed into the same—either party setting their ears before their understanding." "These gentlemen who tease and torture the strings, and rack them upon the pegs of the instrument" would, according to the theory here defended, quite certainly have developed the fifth from its status as an intermediate interval to one of consonance. Their position, we may imagine, was not unlike that of the singers in the fourteenth century who were forbidden by the conservative Pope John XXII to sing thirds, on the

[70] Op. cit., 149.
[71] Jowett's Plato, Republic VII, 530 d, ff.

ground that this interval served only to intoxicate and not to soothe the ear.[72]

Those authors who hold that the fifths and fourths were consonances for the Greeks[73] begin by calling attention to the Pythagorean harmonic proportion 12:8:6, or c-g-c. But the inferences that can be made from this leave much to be desired. In the first place, it is not clear that the Pythagoreans had reference to the consonance of simultaneous tones. The term κρᾶσις employed by them in this connection, was very frequently used to refer to the combination of successive impressions, as of consonants and vowels in speech.[74] And further, it is not clear that their "consonances" were not predetermined to a certain extent rather by calculation and measurement than by the actual report of the senses. At least, according to Boethius,[75] the late Pythagoreans Nikomachus, Eubulides, and Hippasus, obtained each a different classification of the consonances because they founded their calculations on different arithmetical speculations! How remote the Pythagorean "harmony" may have been from the actual harmony of musical combinations, as experienced, may be judged by their much reiterated conception of the harmony of the spheres, which, if it means the simultaneous sounding of all the heavenly bodies, would make out of the cosmos the most atrocious discord.

Plato can be relied on even less than the Pythagoreans to give us an exact notion of the Greek consonances. According to him[76] the intimations of the senses are so imperfect that it is absurd to take pains in investigating the exact truth about them. Just as the true study of astronomy lets the heavens alone so the true study of music limits itself to the natural harmonies of mathematical relations, and reflects not on the harmony of sounds, but on that of numbers.

We have already seen that the only Aristotelean evidence con-

[72] Oxford History of Music, II, 91.
[73] Stumpf, Geschichte des Consonanzbegriffes, 6.
[74] Stumpf, Ibid., 8
[75] Stumpf, Ibid., 55.
[76] Jowett's Plato. Republic, VII, 530 ff.

cerning the consonance of the fourths and fifths is their inclusion among the *συμφωνίαι*. This word is defined by Aristotle as a numerical relation between a high and low tone. There is no mention of a specific difference between consonance and dissonance; in fact, no single word that we can translate by dissonance.[77] *συμφωνία* is usually referred to simply as *λόγος* or relation. Indeed, it is significant that Aristotle asserts, as against the Pythagoreans, Met. N. 6. p. 1093 a. 20-25, that there are more than three *συμφωνίαι* ; Stumpf,[78] in order to translate the Greek by "consonance" in this passage, is obliged to assume that Aristotle refers here to the addition of such intervals as the double octave and twelfth. But if we accept the translation "musical interval," we may interpret this passage, more naturally, it seems to me, as the incipient recognition that smaller and more dissonant intervals than the fourth and fifth are beginning to impress themselves as musically useful.

By the time of Thrasyllos, first century B.C., the classification of intervals has become very definite,[79] but it is noteworthy that the fifth and fourth are put in a class distinct from the octave. Thrasyllos makes a threefold distinction, (1) antiphonies, including the octave and double octave; (2) paraphonies, including the fifth and fourth; (3) diaphonies, including the intervals mentioned in the other two classes. Five centuries after Thrasyllus, the same classification is used by Gaudentius, but a significant change has taken place. The fifth and fourth are ranked by him in the same class with the octave; the third is now a paraphony, and the diaphonies include the intervals more dissonant than the third and tritone.[80] If paraphony, as used by Thrasyllos, is at all comparable to the same expression as used by Gaudentius we cannot but conclude that as late as the first century, B.C., the fifths and fourths were still in the intermediate class, but that by the fourth century, A.D., they had developed into full-fledged consonances. And it is an interesting fact in this connection that

[77] Stumpf, Geschichte des Consonanzbegriffes, 22.
[78] Ibid., p. 34.
[79] Ibid., 48 ff.
[80] Stumpf, Ibid., 69-71.

whereas the Aristotelian Problems speak only of the octave as the most beautiful interval, Bacchius in the fourth century A.D. mentions both the fifth and the octave, with the fifth first in order.[81]

By the ninth century the fifth is obviously a new kind of harmonic experience. The Christian church has found that a more beautiful concord than the octave is to be obtained by having concurrent voices sing in fifths.[82] In its practice of "organizing," the "vox principalis" sang the melody and the "vox originalis" sang the accompaniment in the fifth below in parallel movement. The great pleasure which ninth century singers derived from this sort of music cannot be satisfactorily disposed of with the statement that they merely felt themselves to be diversifying the means by which a melody might be sung in unison. The writings of this period indicate clearly that the interval of the fifth made very much the same appeal to them that the third makes to us to-day. Thus Regino, in his *De harmonica Institutione,* written in 892,[83] "Consonantia est acuti soni gravisque mistura, suaviter uniformiterque auribus accidens. Et contra dissonantia est duorum sonorum sibimet permistorum ad aurem veniens aspera atque iniucunda percussio." Their distinction of consonance and dissonance was evidently quite as definite as ours; the only difference is that the third is as yet distinctly not included among the combinations described as "suaviter auribus accidens."

Taken as a whole, the evidence from the time of Aristotle to that of the ninth century points very strongly to a gradual advance of the fifth from being almost a consonance to being the most acceptable one. The reason why its development should follow next in order after the octave is obvious. Since it is the next simplest ratio 2 : 3, it requires further, according to our theory, only that it be impressed on the hearer sufficiently often. Now we have seen that as regards natural frequency of occurrence in overtones the fifth comes next in order to the octave, since it occurs five times in the first sixteen overtones of any

[81] Ibid., 68.
[82] H. E. Woolredge, Oxford History of Music, Vol. I, Ch. IV.
[83] Woolredge, op. cit., I, 46.

clang. Moreover, it was probably quite often produced in the earliest times by tenor and bass voices calling together naturally at medium pitch. And its development among primitive people would be peculiarly favored by their practice of singing simultaneous melodies. Of this characteristic primitive practice von Hornbostel observes:[84] "Alle diese Formen von Mehrstimmigkeit sind dadurch charakterisiert, dasz mehrere Melodien zwar gleichzeitig erklingen, aber doch noch als Melodien. Auf die einzelnen Zusammenklänge als solche wird wenig oder gar nicht geachtet." Now whenever in such a chaos of sound there appeared a fifth, with its initial advantage of simple ratio and frequent natural occurrence, it is obvious that it would tend to become fixed rather than any other dissonance, and each time it was thus attentively observed its proximity to consonance would be increased. This is exactly what seems to have happened in every case. Those of the primitive and semi-civilized people of to-day who have advanced beyond the stage of parallel octaves, have invariably acquired, as the next step, parallel fifths and fourths. This is true not only of their singing, but of their playing on instruments. Stumpf[85] observes that in China, Japan and Sumatra it is quite usual that instruments make fifths and fourths with each other or with the orchestra.

The shifting division between consonance and dissonance seems to have included the fourth among the consonances almost simultaneously with the fifth. Its development among the Greeks exactly parallels that of the fifth; all the primitive races to-day who treat the fifth as a consonance treat the fourth likewise; and the ninth century "organum" which in its simplest form gave only parallel fifths, gave also parallel fourths when the "vox principalis" was doubled an octave above, and the "vox originalis" an octave below. But the simultaneous development of these two intervals may be readily understood according to the principle of the equivalence of octaves. That is to say, the resemblance between any note and its octave is now so strong that the presentation of

[84] E. von Hornbostel, Ueber vergleichhende akustische und Musik-psychologische Untersuchungen, p. 484. Zeitschrift für Angew. Psych. III, 1909.

[85] Anfänge der Musik.

any given fundamental is practically equivalent to the presentation of its octave. Hence, whenever a fourth was sounded, it could be heard, not as a new interval different from the fifth, but merely as the old interval inverted—and even perhaps a little more interesting, because of the slight increment of difficulty. The same principle explains the later simultaneous development of thirds and sixths; it is indeed the fundamental fact in all the triad inversions of modern harmony.[86] It is significant, however, that by the time of Guido of Arezzo, the first half of the eleventh century, the foundation of the Diaphony or Organum was no longer the fifth, but the fourth.[87] The perfect fifth has ceased to be the barely consonant and therefore intrinsically interesting interval it had been two centuries previously. As it becomes more consonant it becomes less available as a parallel interval.

The major third 4 : 5 is the simplest of the dissonances that now remain, and history merely repeats itself when the third by frequent hearing gains a place among the consonances. The possibility of its attracting especial attention was obtained when the strict form of Diaphony, which was based entirely upon the traditional concords, was relaxed in favor of free Diaphony, which admitted sounds that were discordant, provided they were not introduced consecutively or on an accented beat.[88] We find it recognized in the eleventh century *Micrologus* of Guido of Arezzo, who illustrates the pleasant effect of coming to the unison by way of the major third.[89] This is at a time when the minor third is still forbidden even in passing. By the twelfth century there is evidence of the use of both major and minor thirds and sixths provided they are treated lightly. A twelfth century manuscript of the British Museum, published by Coussemaker in his *Histoire de l'Harmonie au Moyen Age,*[90] gives the following very explicit regulations with respect to the progression after thirds and sixths: "The minor third requires the unison after it; the major third, the fifth; the minor sixth, the fifth; the major

[86] Stumpf, Konsonanz und Konkordanz, Zeitsch. für Psych. 58,334.
[87] Woolredge, op. cit., I, 63.
[88] Woolredge, op. cit., I, 66.
[89] Ibid., 66.
[90] See Woolredge, op. cit., Chap. VI.

sixth, the octave." These intervals at this time evidently had their "regular" resolutions in much the same sense that the dominant seventh has its regular resolution in the harmony of to-day. The interesting transformation which has taken place in the third in the last seven hundred years is described summarily by Parry,[91] when he says, "whereas in modern times a man feels that he wants something more when he is without it, in medieval times he wanted something more because he had it." A twelfth century writer, comparing his own sense of consonance with that of the Greek, might have made exactly the same statement in regard to the fifth; for this interval left the Greek with a sense of disturbed equilibrium,[92] whereas in the twelfth century it was the regular resolution of the major third and minor sixth. The exact steps by which the almost consonant third became generally recognized as a consonance cannot be traced with certainty. Riemann[93] thinks the practice of singing in parallel thirds and sixths appeared earlier in England than on the continent, and that it spread from England to France. This, however, is thought very doubtful by Woolredge.[94] What interests us especially here is the fact that it seems to have had for a considerable time the characteristic attribute of an intermediate interval; that is, it had become a consonance to some ears, while it was yet a dissonance to others.[I] Pope John XXII, in a decree —1322—forbidding the use of discant, said: "Yet for all this, it is not our intention to forbid occasionally, and especially upon feast days or in the solemn celebration of the mass . . . the use of . . . the octave, fifth and fourth which heighten the beauty of the melody. . . . Used in such sort, the consonances would both soothe the hearer and arouse his devotion."[95] This decree, which excluded thirds, was set aside just fifty-five years

[91] Evolution of the Art of Music, 88.

[92] Aristotelian Problems, 39 b.

[93] Geschichte der Musiktheorie im IX-XIX Jahrhundert.

[94] Op. cit., I, 161 ff.

I. We have already compared this state of affairs with the one that probably existed in Greece at one time regarding the fifth. We shall see later that the natural seventh 4:7 to-day manifests the same characteristic.

[95] Op. cit., I, 91.

later, when official recognition was given to the Faulx Bourdon, a form in which consecutive thirds and sixths were the rule. Obviously the ultra-moderns in the musical taste of that time had continued to exert such a pressure that the conservatives finally came to acknowledge their point of view as the better one.

The decline of the fourth and fifth seem just about to have kept pace with the advance of the third. Thus Simon Tunstede, an English theorist of the year 1400, in his *Quattuor Principalia,* writes:[96] "Let him who is to discant avoid as much as possible the perfect concords (i.e., fifths and fourths), keeping his part in the imperfect intervals, that is to say, in the thirds, sixths and tenths above the tenor, and with these let him discourse, ascending and descending according as it may seem to him expedient and most agreeable to the hearer." Thus the fifth and fourth, as they grew more consonant, lost the attribute which invariably belongs to the least consonant of the consonances, namely, the pleasing effect as a parallel interval.

Two possible arguments suggest themselves for maintaining the essentially consonant character of the third despite the slowness with which its recognition developed. The first is the fact that the earliest third was not the natural major third 4:5 but the Pythagorean 64:81. And indeed Helmholtz[97] suggests this as a possible reason for its treatment as a dissonance. But he himself admits later on [98] that "even when the natural major third was included in the so-called syntono-diatonic mode of Didymus and Ptolemaeus, it was not recognized as a consonance." And besides, recent experiments have shown that an interval can be considerably mistuned while continuing to give its characteristic fusion effect. It would seem then that very little weight can be attached to the slight discrepancy of the Pythagorean ratio.

A second argument is that the medieval man was so bound by what had been established before him that he refused to admit anything for which he could find no precedent in tradition. Such

[96] Woolredge, op. cit., II, 111.
[97] Sensations of Tone, 190.
[98] Op. cit., 228.

an argument, if it did not concern the immediate facts of sense, would deserve careful consideration. Certainly the medievals had an extraordinary respect for established rules, but that they could have maintained in theory what their ears were constantly upsetting in practice, that they could have heard thirds as we hear them, and yet have described their impressions as they described them,—this passes understanding.

The primitive people of to-day among whom has been found the practice of singing or playing in passages of thirds are very rare, and even then it is always a question how far European influence has found its way among them. But at least it is certain that the third has invariably been the interval acquired next after the fifths and fourths. Thus G. Knosp[99] reports that the Annamites found the major triad beautiful, but the minor triad and all seventh chords were horrible and meaningless. Stumpf[100] reports that a member of the Siamese court orchestra, tested by him, thought our major triad pleasing, but disliked the minor triad and dominant seventh.

It might be argued that since the Siamese scale is totally different from ours, the liking of this subject for our major triad is an argument against gradually developing fusion grades. But such a conclusion does not follow from the facts. In the first place, it is to be noted that this Siamese, whom his fellows named as the best musician among them, had already gained some familiarity with European music both in Vienna and at home. He was accordingly so far spoiled in respect to being a typical example of Siamese musical evolution. And furthermore, it is certainly possible to find an interval acceptable without feeling it as a consonance. The twelfth century musician expressed satisfaction with the third—for him a dissonance—provided it was preceded and followed by a consonance, and we ourselves do as much for the dominant seventh which we still class as a dissonance. The distinction between degree of pleasure and degree of consonance is one on which every writer now insists.[101] But

[99] E. von Hornbostel, op. cit., 486.
[100] Tonsystem und Musik der Siamesen, Akustik und Musik, III.
[101] Stumpf, Akustik und Musik, I, 30-34.

for this distinction we should have to consider the third at present more consonant than the fifth. And lastly, if the Siamese felt the various fusion grades in the same way as a European, it might be asked why he should have objected to passages of thirds,[102] and why he should have disapproved of the minor triad and of the seventh chord. So far as the facts presented warrant any judgment as to the Siamese's distinction of consonance and dissonance, we should have to say that for him the minor third is more dissonant than is the minor seventh for us, while the major third may or may not be.

The difficulty of getting definite results from the questionnaire method with primitive people, or any people differing widely from ourselves, is illustrated by the attempts of von Hornbostel to get judgments from a group of North American Indians concerning various consonant and dissonant combinations.[103] Every possible answer was obtained with regard to every chord! Myers[104] in the article previously mentioned, refers with considerable dissatisfaction to the attempts so far made to investigate the affective value of various pairs and triads of tones presented to savages. He says: "It is clear that both native and European intervals should be presented, that the intervals should be sounded on native and not merely on European instruments, and that repeated judgments must be obtained before reliance can be placed on such comparisons. Investigators have hoped to arrive at an answer by playing primitive melodies on the piano, harmonizing them now in one way, now in the other. But the likes, dislikes, or indifferences of the natives, ascertained by such a rough method of experiment, cannot be accepted as trustworthy." The only test of this sort which I was able to make in connection with the present investigation was to try the comparative effect of parallel fifths and thirds on one Japanese and two Chinese students at Harvard. The answer from one of them was uniformly that they were "just the same." Both of the other men usually gave a similar answer, but so far as any

[102] Stumpf, Tonsystem und Musik der Siamesen, 106.
[103] E. von Hornbostel, op. cit., 486.
[104] C. S. Myers, op. cit., 2.

preference was expressed it was for the fifths, despite the fact that they had lived in this country for a year and a half. The inconclusiveness of these results is typical of what seems likely to be obtained by any method short of a prolonged and systematic investigation. Surely, until an exact understanding can be guaranteed between the experimenter and his subject, the safest guide in the matter of consonance and dissonance is the actual musical practice of a people, and this we find in such cases is limited almost entirely to the intervals of the octave, fifth and fourth.

If the test for the complete establishment of an interval as a consonance is its use in the final chord of a cadence,[105] the first historical example of the complete establishment of the third is in the Nesciens Mater, 1450,[106] which offers a cadence in which the middle voice passes to the third instead of the fifth. The minor chord was avoided in closes down to the time of Bach, and even Handel and Mozart occasionally indicate their desire to give greater finality to a minor piece by ending it with a major chord.[107] Once admitted as a consonance, the minor third has not relegated the major to a position of lower importance, but rather the constant interchanges of the two have tended to enhance the feeling value of both. It is practically impossible in our present diatonic system to get a succession of thirds which are entirely major or minor. What we get in any passage is a frequent alternation between the two; that is, between the slightly less and the slightly more consonant. This situation has been of immense advantage in maintaining the third as the most interesting interval. It has been thus doubly fortified against gradual reduction to the status of an "empty" interval as the octave and fifth before it.

Of the sixths little more need be said than that their development as consonances parallels that of the thirds. Although slightly more complex in ratio than the latter, they give, owing to the equivalence of octaves before mentioned, more the effect of inverted thirds than of intervals in their own right. Their

[105] Parry, Evolution of the Art of Music, 88.
[106] Oxford History of Music, II, 139-142.
[107] Helmholtz, op. cit., 217.

simultaneous development with the thirds is accordingly to be explained on exactly the same grounds as that of the fourths with the fifths,

The next simplest ratio is the natural seventh 4 : 7. Its effect is peculiarly interesting on account of the fact that its development has been arrested, owing to its exclusion from the diatonic scale. It remains to-day an intermediate interval, and we find, as is to be expected, wide individual differences of opinion as to its status. Stumpf[108] considers it intermediate between consonance and dissonance; Hohenemser[109] and the Lippsians in general consider it a pronounced dissonance; Helmholtz[110] thought it nearer to the consonances than the dissonances; and Krueger[111] and many others think it belongs distinctly among the consonances. These differences recall the state of affairs, already mentioned, in regard to the third in 1322, and make even more plausible the conjecture that has been made with regard to the fifth among the Greeks. They suggest further that if the 4 : 7 were included among the intervals in regular use, its frequent hearing would presently make it unquestionably consonant for all ears. This consonance would be less complete than its predecessors, but therefore all the more interesting. Unfortunately there is no instrument which makes possible with the 4 : 7 the kind of experiments which I am here reporting on the thirds, fifths, minor and major sevenths, but there is every reason to believe that when similar tests can be devised the results will be of the same kind.

By the time of Palestrina, 1524-1594, the division was definitely marked between the thirds on the one hand and the minor seventh 5 : 9 on the other. The change of attitude that has since taken place toward the latter interval is in every way indicative of a general progress in the direction of consonance. Palestrina treated the minor seventh just as the twelfth century musicians treated the third in free Diaphony. He allowed it, but only as

[108] Differenztöne und Konsonanz, Zeitschrift für Psych. 59, 164.
[109] Krueger, op. cit., II, 219.
[110] Sensations of Tone, 195.
[111] Krueger, op. cit., 219.

an "unessential" discord; that is to say, as a suspension or passing note. It thus appeared in a transient juxtaposition of voices while the main interest was directed to the movement of the parts themselves. But, shortly afterwards, interest began to attach to the interval on its own account, and Monteverde, 1567-1643, upset all traditions by attacking the dominant seventh and leading tone seventh directly without preparation.[112] The more recent developments are familiar to every student of harmony. Not only was the dominant seventh later allowed to enter unprepared, but feeling gradually developed in favor of extending the same license to the secondary sevenths, until now any chord of the seventh may be directly introduced without giving offense. At the same time, the feeling that the seventh required a "regular" resolution has undergone a marked alteration. In many passages from Parsifal, for example, one can see that Wagner, by the same device of passing notes which Palestrina used to introduce a single interval of a seventh, contrives to produce transient artificial chords with sevenths which are succeeded by new chords with other sevenths. These passing note combinations mark the incipiency of parallel sevenths just as surely as the sevenths occurring frequently in half closes in *Tristan and Isolde* point to the ultimate possibility of a complete close containing a seventh. But the precaution which Wagner takes in introducing his sevenths only when attention is concentrated on the melodic progression of the parts, is brushed aside by his more modern successors. Strauss is to Wagner in this respect as Monteverde is to Palestrina. The consecutive sevenths which Wagner suggests more or less indirectly, are attacked by Strauss without any relieving contrapuntal device. The climactic parts of *Heldenleben,* and the succession of chords which comes at the end of the song *Morgen,* are but two of the numerous instances of consecutive dominant sevenths which before Strauss would have been considered absolutely impossible. More decided still is an example from Florent Schmitt's *Tragédie de Salome* in which we have a passage of ten successive sevenths.

[112] Helmholtz, op. cit.

It is needless to multiply instances of what contemporary orchestral compositions are coming more and more to abound in.

It might be argued that the composer is merely trying to add a novel interest to his work by daring to use progressions that would have been considered too bold by his predecessors. But a composer's choice of means is never entirely irrelevant to the potential capabilities of his hearers. His startling effects, if true products of art, must end by introducing them to a new and more ultimate pleasure. "We must suppose that the great composer builds somewhat better than he knows, in that his radical harmony is not a mere bit of wanton freakishness, but a more or less unconscious finding his way to the next stage in the musical progress of the race." If this is true, the rapidly developing freedom of treatment of the minor seventh in present-day music urges strongly the experimental investigation of the effect of repeatedly hearing this dissonance which bids fair to become a consonance.

But, before proceeding to an examination of experimental results, it will be well to summarize the main points of historical development. The qualitative distinction between consonance and dissonance has at all times had most immediate reference to the self-sufficiency which always exists for the one and never for the other. The practical test of self-sufficiency, and therefore of consonance, we have taken to be the immediate effect of the interval in a passage of parallels. On the basis of this distinction we may say that the history of each of our present consonances has apparently been a gradual development as dissonance, followed by a relatively short transition period, and later a gradual development as consonance. The typical case, in which we may observe all the gradations, is that of the third. As a dissonance it was at first too harsh for any use at all, but afterwards was considered a useful interval if properly restricted. Then follows a transition during which some seem to have felt it as a consonance while others still considered it dissonant. Later comes its general admission as a parallel interval, and still later its use in the final chord of a cadence. Each stage, we have seen, had its characteristic pleasure value. As a decided dissonance

it was essentially unpleasant; as a mild dissonance it was pleasant according to the context; as a bare consonance it was essentially pleasant, as for example to Monteverde, who confessed his inordinate fondness for thirds; when it becomes a more perfect consonance it begins to take on a more empty character, as is instanced by our present growing dissatisfaction with such music as that of Donizzetti. The history of the fifth exemplifies the end of this same general process; that of the minor seventh its beginning. The fifth, recognized by the Greeks as more like the octave than any of the other intervals, though most probably not at that time a consonance in our sense, appears in the ninth century as the sweetest of concord. A few centuries later it has lost in content until consecutive fifths are becomtaboo; and the present-day effect of the fifth reminds one of the answer of Rossini to the question, "What is more *langweilig* than a flute?" His answer was, "Two flutes." The fifth to-day is a most essential element in the structure of harmony, but considered *per se* it has an unpleasant barrenness for most ears, so that it is not used consecutively except for particular effects. The seventh, altogether too harsh for the twelfth century ear, comes later to give much pleasure in the mildly dissonant chord of the dominant seventh, and the boldness of contemporary radicals augurs for it an eventual transition to the recent status of the third, that of the most pleasant of consonances.

CHAPTER V

Experimental Evidence

The experiments which I shall report were performed on nine subjects during the winter of 1913-1914 under the direction of Professor Münsterberg and Doctor Langfeld in the Harvard Laboratory. The intention was to examine the characteristic effects of prolonging and repeating two consonances, the fifth and third, and two dissonances, the major and minor seventh, with a view to ascertaining whether the facts thus obtained would lend support to such an interpretation of the genesis of consonance as has been given above .

The requirements to be fulfilled by the instruments to be used were,

(1) That it be possible to sustain an interval for any length of time and at fairly uniform pressure.

(2) That two successive chords or intervals could be compared, each having been played for the same length of time and with the same amount of pressure.

(3) That passages of any desired number of parallel intervals could be played at any speed desired.

The Tonmesser and harmonium are obviously not adapted for this last requirement; it was therefore necessary to use a cabinet organ with tempered scale. The one used was an instrument made by the Estey Organ Company, Boston. The stop exclusively used was a melodia with very prominent second, third, and fourth overtones.

PRELIMINARY EXPERIMENT

Since the final conclusions were to rest on an interpretation of the subjects' comparative judgments of intervals under different conditions, it was necessary first of all to compute for every subject a co-efficient of musical consistency obtained from a series of judgments under constant conditions. And, further, since the final results were to have to do with the question of

consonance and dissonance, it was desirable to find out in advance how far the subject naturally inclined in his preferences toward the one or the other. In short, the intention of the preliminary experiment was twofold, to find out in the case of each subject his degree of consistency and his degree of consonance.

As stimuli for paired comparison in the preliminary experiment, I used nineteen resolutions of the dominant seventh chord. The expression "resolution" in these experiments is to be understood as meaning a pair of chords; the dominant seventh plus the chord into which it resolves. A comparison of resolutions hence means a comparison between two pairs of chords. The actual chords used, and their corresponding numbers as they appear in the tables follows. It will be seen that eight of the

RESOLUTIONS OF DOMINANT SEVENTH USED IN PRELIMINARY EXPERIMENT.

resolutions, 9, 10, 11, 12, 15, 16, 17, 18, are dissonant; the rest consonant.

Each of the nineteen resolutions was compared with each of the others in an irregular series, and then the same comparisons were made with the pairs presented in the reverse order. This made in all three hundred and forty-two judgments, given under conditions such that memory could not possibly have had any influence in determining the choices. The time during which each pair was sounded was kept constant by allowing two seconds for the dominant seventh and three for the following chord, mak-

ing five seconds for the whole pair. An interval of two seconds was allowed between the resolutions.

In the individual tables, which follow immediately, the preferred resolutions are indicated by the numbers in the square. The two resolutions compared are to be found by passing from a given square upward to the number at the top of the column, and laterally to the number at the left side. Thus in the first table resolution number 1 was preferred to 2 both when it came before and when it came after it in order of presentation. The letters referring to the subjects throughout the tables are as follows:

B — Mr. J. W. Bridges
T — Mr. H. E. Burtt
C — Mr. R. A. Cutting
G — Mr. R. C. Givler
K — Mr. C. E. Kellogg
L — Dr. H. S. Langfeld
M — Miss O. Martin
S — Mr. W. M. Marston
R — Mr. A. A. Roback

TABLE I

B

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	×	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	=
3	1	2	×	3	3	3	7	8	9	3	3	3	13	3	3	3	3	3	19
4	1	2	3	×	4	6	4	8	4	4	11	4	13	4	4	4	4	4	19
5	1	2	3	4	×	6	7	5	5	5	5	5	13	5	5	5	5	5	19
6	1	2	3	6	6	×	7	8	6	6	6	6	6	6	6	6	6	6	6
7	1	2	3	7	5	6	×	8	7	7	=	7	13	7	7	7	7	7	19
8	1	2	3	8	8	6	8	×	8	8	8	8	8	8	8	8	8	8	19
9	1	2	3	4	5	6	7	8	×	9	=	12	13	14	9	16	9	9	19
10	1	2	3	4	5	6	7	8	10	×	=	12	13	14	15	10	10	10	19
11	1	2	3	11	11	6	11	11	11	11	×	11	13	11	11	11	11	11	19
12	1	2	3	4	5	6	7	8	9	10	11	×	13	14	=	16	12	12	19
13	1	13	13	13	13	13	13	13	13	13	13	13	×	13	15	13	13	13	=
14	1	2	3	4	5	6	7	8	14	=	11	12	13	×	15	16	14	14	19
15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	×	15	15	18	19
16	1	2	3	4	5	5	7	16	9	16	11	12	13	16	15	×	17	18	19
17	1	2	3	4	5	6	7	8	9	10	11	12	13	14	17	16	×	18	19
18	1	2	3	4	5	6	7	8	9	10	11	12	13	18	15	16	17	×	19
19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	×

TABLE II

T

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	1	1	1	5	1	7	8	9	1	1	1	1	14	1	1	1	1	19
2	2	×	2	2	5	2	2	8	9	2	2	2	2	14	2	2	17	2	19
3	1	2	×	3	5	3	3	8	3	3	3	3	13	14	3	3	3	3	19
4	1	2	3	×	5	6	4	8	9	4	11	4	4	14	4	4	4	4	19
5	1	5	5	5	×	5	5	8	9	5	5	5	5	14	5	5	5	5	19
6	1	2	3	6	5	×	6	8	6	6	11	12	6	14	15	6	6	6	19
7	1	2	3	7	5	7	×	8	9	7	11	7	7	14	7	7	7	7	19
8	1	8	8	8	5	8	7	×	8	8	8	8	8	14	8	8	8	8	19
9	1	2	9	9	5	9	9	8	×	9	9	9	9	14	9	9	9	9	19
10	1	2	3	4	5	6	7	8	9	×	11	12	12	14	15	16	10	10	19
11	1	2	3	4	5	11	7	8	9	11	×	11	13	14	15	16	11	11	19
12	1	2	3	4	5	12	7	8	9	10	11	×	13	14	12	16	12	12	19
13	1	2	13	13	5	13	13	8	9	13	13	13	×	14	13	13	17	13	19
14	14	14	14	14	5	14	14	14	14	14	14	14	14	×	14	14	14	14	19
15	1	2	3	4	5	15	15	8	9	15	11	15	13	14	×	16	15	15	19
16	1	2	3	4	5	16	7	8	9	16	11	16	13	14	16	×	16	16	19
17	1	2	3	4	5	6	7	8	9	17	11	17	13	14	15	17	×	18	19
18	1	2	3	4	5	6	7	8	9	10	11	12	13	18	15	16	18	×	19
19	19	19	19	19	5	19	19	=	19	19	19	19	19	19	19	19	19	19	×

TABLE III

C

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	2	3	4	1	6	1	1	9	1	1	1	1	1	1	1	1	1	19
2	1	×	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	19
3	1	3	×	4	3	3	7	3	3	3	3	3	3	3	3	3	3	3	19
4	1	2	4	×	4	4	4	4	9	4	4	12	13	4	15	4	4	4	19
5	5	2	5	5	×	6	7	5	5	5	5	5	13	5	15	5	17	5	19
6	1	2	6	4	5	×	6	6	9	6	6	6	6	6	6	6	6	6	19
7	7	2	3	7	7	7	×	7	9	7	7	12	13	7	15	7	7	7	19
8	8	8	8	4	5	8	7	×	9	10	11	12	13	8	15	8	8	18	19
9	1	9	9	9	5	9	7	9	×	9	9	12	13	9	9	9	9	9	19
10	1	2	3	4	5	10	10	10	9	×	11	12	13	14	15	16	17	10	19
11	11	2	3	11	5	11	7	11	11	11	×	12	13	11	15	11	11	11	19
12	12	2	3	4	12	6	7	8	9	12	12	×	13	12	15	12	12	12	19
13	1	13	13	13	13	13	13	13	13	13	13	13	×	13	15	13	13	13	19
14	1	2	3	14	5	6	7	14	9	14	14	14	13	×	15	14	17	14	19
15	1	15	15	4	15	15	15	15	15	15	15	15	13	14	×	15	15	15	19
16	1	2	16	16	5	16	16	16	9	10	=	12	13	16	15	×	17	18	19
17	17	2	17	17	5	17	17	17	17	10	11	12	13	17	15	17	×	17	19
18	1	2	3	18	5	6	18	18	18	10	18	18	13	14	15	16	18	×	19
19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	×

TABLE IV
G

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	1
2	2	×	2	2	2	2	7	2	9	10	11	12	13	14	15	16	17	18	2
3	3	3	×	4	3	=	7	3	9	10	11	=	13	14	15	16	17	18	3
4	4	4	4	×	5	=	7	4	9	10	11	=	13	14	15	16	17	18	4
5	5	5	5	5	×	5	7	5	9	10	11	12	13	14	15	16	17	18	5
6	6	2	3	6	5	×	7	8	9	10	11	12	13	14	15	16	17	18	6
7	7	7	7	7	7	7	×	7	7	10	11	12	13	14	15	16	17	18	7
8	8	2	3	8	5	8	7	×	9	10	11	12	13	14	15	16	17	18	8
9	9	9	3	9	9	9	9	9	×	10	11	12	13	14	15	16	17	18	9
10	10	10	10	10	10	10	10	10	10	×	10	10	10	14	15	16	17	18	10
11	11	11	11	11	11	11	7	11	11	10	×	12	13	14	15	16	17	18	11
12	12	12	12	12	12	12	12	12	12	10	12	×	=	14	=	16	17	18	12
13	13	13	13	13	13	13	7	13	9	10	11	12	×	14	15	16	17	18	13
14	14	14	14	14	14	14	14	14	14	10	14	14	=	×	14	16	14	18	14
15	15	15	15	15	15	15	15	15	15	10	15	15	15	15	×	16	17	18	15
16	16	16	16	16	16	16	16	16	16	10	16	16	16	16	=	×	16	18	16
17	17	17	17	17	17	17	17	17	17	17	17	=	17	17	17	17	×	=	17
18	18	18	18	18	18	18	18	18	18	10	18	18	18	18	18	18	=	×	18
19	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	×

TABLE V
K

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	2	3	4	1	1	1	8	1	1	11	1	13	14	1	1	1	1	19
2	2	×	=	4	2	2	2	=	2	2	11	12	13	14	2	2	2	2	=
3	1	2	×	3	3	3	3	8	3	3	11	3	13	3	3	3	3	3	19
4	4	2	3	×	5	4	=	8	4	4	=	12	13	14	4	4	4	4	19
5	5	2	3	5	×	6	5	8	9	5	5	5	13	14	5	5	5	5	19
6	6	2	3	6	5	×	6	8	6	6	11	12	13	14	6	6	6	6	19
7	=	2	3	7	5	7	×	8	7	7	11	7	13	14	7	16	7	7	19
8	8	8	3	8	=	8	8	×	8	8	8	8	13	=	15	8	8	8	8
9	9	2	3	=	5	9	9	8	×	9	11	9	13	14	9	9	9	9	19
10	1	2	3	4	5	10	7	8	9	×	11	10	13	14	15	16	10	10	19
11	11	2	3	4	11	11	7	8	9	11	×	11	13	14	11	11	11	11	19
12	1	2	3	4	5	6	7	8	9	12	11	×	13	12	15	12	12	12	19
13	13	13	=	13	13	13	13	8	=	13	13	13	×	=	13	13	13	13	=
14	14	2	3	14	14	14	14	8	14	14	14	14	13	×	14	14	14	14	14
15	1	2	3	4	15	6	7	8	9	10	15	15	13	14	×	15	17	15	19
16	1	2	3	4	5	6	7	8	9	16	11	16	13	14	16	×	16	16	19
17	1	2	3	4	5	6	7	8	9	10	11	17	13	14	15	16	×	17	19
18	1	2	3	4	5	6	7	8	9	10	11	12	13	14	18	16	18	×	19
19	19	19	=	19	19	6	19	19	19	19	19	19	=	14	19	19	19	19	×

TABLE VI

L

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	1	1	1	5	6	1	1	1	10	11	1	13	1	1	1	1	1	1
2	1	×	2	2	5	6	7	2	9	10	2	12	13	2	2	16	2	18	2
3	1	3	×	4	3	3	7	3	9	3	3	3	13	3	3	3	3	3	3
4	4	4	3	×	4	4	4	4	4	4	4	4	13	4	15	4	4	18	4
5	1	5	5	5	×	5	5	5	9	5	5	12	13	5	5	5	5	18	5
6	1	6	6	4	6	×	7	6	6	10	11	12	6	14	15	6	17	18	6
7	7	7	7	7	5	7	×	7	7	10	11	7	7	7	15	7	7	18	7
8	8	8	3	4	5	6	7	×	9	10	11	12	13	8	15	16	17	18	8
9	9	9	9	9	9	9	7	9	×	10	11	12	9	9	9	9	9	9	9
10	1	10	3	10	10	10	7	10	10	×	11	10	13	10	15	16	10	18	10
11	1	2	3	4	11	11	7	11	11	10	×	11	13	11	15	16	17	18	11
12	1	12	12	4	5	12	12	12	9	10	12	×	12	12	12	16	12	18	12
13	1	13	13	13	13	13	13	13	13	13	13	13	×	13	13	16	13	18	13
14	1	2	3	4	5	6	7	14	14	10	11	12	14	×	15	14	17	18	14
15	1	15	15	15	15	15	15	15	15	15	15	15	15	15	×	15	15	18	15
16	1	16	3	4	5	6	7	16	9	16	11	12	13	14	15	×	17	18	16
17	1	17	17	4	17	17	17	17	17	10	11	17	13	17	15	17	×	18	19
18	18	18	3	18	18	18	18	18	18	18	18	18	13	18	18	18	18	×	18
19	19	2	3	4	5	6	7	8	9	10	11	12	13	14	15	19	19	18	×

TABLE VII

S

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	2	3	1	1	1	1	1	1	1	1	1	13	1	1	1	1	1	19
2	2	×	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	19
3	1	2	×	3	3	3	3	8	3	3	3	3	13	14	3	3	3	3	19
4	1	2	3	×	5	4	4	8	4	10	4	4	13	14	4	4	=	4	19
5	1	2	3	5	×	6	7	8	5	5	11	5	13	5	5	5	5	5	19
6	1	2	3	6	6	×	6	6	6	=	6	6	13	6	=	6	6	6	19
7	1	2	7	7	5	7	×	8	7	7	7	7	13	=	7	7	7	7	19
8	1	2	3	8	8	8	8	×	8	8	8	8	8	8	8	8	8	8	19
9	1	2	3	4	=	9	7	8	×	9	9	9	13	14	9	9	=	9	19
10	1	2	3	4	5	6	7	8	9	×	10	10	13	14	10	16	10	10	19
11	1	2	3	=	5	6	7	8	11	11	×	11	13	11	=	=	11	18	19
12	1	2	3	4	5	6	7	8	=	12	12	×	13	14	15	=	=	18	19
13	13	2	13	13	13	13	13	13	13	13	13	13	×	13	13	13	13	13	19
14	1	2	3	4	5	6	7	8	14	14	14	13	14	×	14	14	14	14	19
15	1	2	3	=	5	15	7	8	15	10	15	15	13	14	×	16	15	15	19
16	1	2	3	4	5	6	7	8	9	10	=	12	13	14	15	×	16	=	19
17	1	2	3	4	5	6	7	8	=	10	11	17	13	14	15	17	×	17	19
18	1	2	3	4	5	6	7	8	9	10	11	=	13	14	15	=	=	×	19
19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	×

TABLE VIII

M

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	2	3	1	1	1	1	1	1	1	1	1	13	1	1	1	1	1	19
2	2	×	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	19
3	1	2	×	3	3	3	3	3	3	3	3	3	13	3	3	3	3	3	19
4	1	2	4	×	4	6	4	4	4	4	4	4	13	4	4	4	4	4	19
5	1	2	3	4	×	5	7	5	5	10	11	5	13	5	5	16	5	8	19
6	1	2	6	4	6	×	6	6	6	6	6	6	13	6	6	6	6	6	19
7	1	2	7	4	7	6	×	8	7	7	7	12	13	7	15	7	7	7	19
8	1	2	3	8	8	8	8	×	8	8	8	8	13	8	8	8	8	8	19
9	1	2	9	9	9	6	7	9	×	10	9	9	13	14	9	9	9	18	19
10	1	2	10	4	10	6	10	10	10	×	11	10	13	10	10	10	10	10	19
11	1	2	3	11	11	6	11	11	11	10	×	11	13	11	11	11	11	18	11
12	1	2	3	4	5	12	12	8	12	10	12	×	13	14	15	12	17	12	19
13	1	2	13	13	13	13	13	13	13	10	13	13	×	13	13	13	13	13	19
14	14	2	14	4	14	6	7	8	9	14	14	14	14	×	14	14	14	14	19
15	1	2	3	4	15	6	15	8	15	10	11	15	13	15	×	15	15	15	19
16	1	2	3	4	16	6	7	8	9	10	11	16	13	16	15	×	17	18	19
17	1	2	3	4	17	6	7	8	9	10	11	17	13	17	17	17	×	18	19
18	1	2	18	4	18	6	7	8	18	10	18	18	13	14	18	18	17	×	19
19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	×

TABLE IX

R

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	×	2	3	1	5	6	7	1	9	10	11	12	13	14	15	1	1	18	19
2	1	×	3	4	5	6	7	2	2	10	11	12	13	14	15	16	17	18	19
3	3	2	×	3	5	6	7	8	3	3	3	3	13	14	3	16	3	18	3
4	1	4	3	×	5	6	7	8	4	10	4	12	13	4	15	16	4	18	4
5	5	5	3	5	×	6	5	8	9	5	5	5	13	14	5	16	5	18	19
6	6	6	3	6	6	×	6	8	6	6	6	6	6	6	6	6	6	18	19
7	1	7	3	4	7	7	×	7	7	10	7	7	13	14	15	7	7	18	19
8	1	8	3	8	5	6	8	×	8	10	8	12	13	8	15	8	8	18	19
9	9	9	3	4	9	6	7	9	×	10	11	12	13	14	9	9	17	18	19
10	10	10	3	10	10	6	7	10	10	×	11	12	13	10	10	10	17	18	10
11	1	11	3	4	5	6	11	8	11	10	×	12	13	14	15	11	17	18	19
12	12	12	3	4	5	6	7	8	9	10	11	×	13	12	12	16	17	18	19
13	1	13	13	13	5	6	13	8	13	13	11	13	×	14	13	16	17	13	19
14	14	14	14	4	5	6	14	8	14	10	11	14	13	×	16	16	17	18	19
15	15	15	3	15	5	6	7	8	9	10	11	15	13	14	×	16	17	18	15
16	1	16	3	4	5	6	16	16	16	10	11	16	13	14	15	×	16	18	19
17	1	17	3	4	5	6	7	8	17	17	17	17	13	14	15	16	×	18	17
18	18	18	3	4	18	6	18	18	9	18	11	18	13	18	15	18	18	×	18
19	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	×

By representing the judgment "better than" by the symbol > we can express briefly each subject's order of preference according to the total number of votes for each resolution, as follows:

Bridges, 1>19>2>13>6>3>8>11 = 7>4 = 5>9>12>10>14>16>15>18>17

Burtt, 19>14>5>8>9 = 2>1>3>13>7>4>11>16 = 15>12>17>6 = 10>18

Cutting, 19>13>2>15>1>3>9>5>4 = 7>6>12>17>11>14>18>16>10>8

Givler, 18>17>16>10>14>15>12>13>11>7>9>5>2 = 3>4>8>6>1>19

Kellogg, 13>8>19>14>3>2>11>5>4>9>1>6 = 7>10>12 = 15 = 16>17>18

Dr. Langfeld, 18>13>15>1>7 = 4>10 = 9 = 5 = 3>12>11>17>6>16 = 2>14>8>19

Marston, 19>2>13>1>8>3>7>5>6>14>4>9>15>10>11>16>17>12>18

Miss Martin, 19>2>1 = 13>3 = 4 = 6>8 = 10>7 = 11>14>9>18>15>5 = 17>12>16

Roback, 6>18>13>3>5 = 10>7 = 8>14>15 = 16 = 4>17 = 11>19>1>12>9>2

Now, if a subject is perfectly consistent in his judgments, we may expect that the preference of one resolution over another, as indicated by the total number of votes for each, will not be contradicted when the two resolutions are directly compared. Thus perfect consistency in the case of the first subject, Bridges, would mean that he will always prefer number 1 to any other resolution; 19 to any other resolution but 1; and 2 to any other but 1 and 19; also that 11, when directly compared with 7, ought to be judged equal to it, and so on. The method of computing the amount of deviation from perfect consistency may be seen by the calculation of Bridges' consistency for resolution number 4. This, according to the order of preferences by total votes, ought to have been judged <1, 19, 2, 13, 6, 3, 8, 11, 7; equal to 5; and >9, 12, 10, 14, 16, 15, 18, 7. It is compared

directly with each of these twice; and whenever both of the direct judgments coincide with the order of preference we may grade the pair 1.00; if one agrees and the other disagrees, the grade will be .50; if one which should be judged equals gets one equals judgment, while the other is > or <, we may grade this pair .75. The coefficient for all the judgments with reference to a given resolution will then be an average of the percentages for the 18 pairs, and the final coefficient for the whole series of 342 judgments will be obtained by a general average of the 19 separate averages.

Bridges' results for resolution number 4 were:

Preference by votes.	By direct comparison.		Consistency.
4 < 1	<	<	1.00
19	<	<	1.00
2	<	<	1.00
13	<	<	1.00
6	<	<	1.00
3	<	<	1.00
8	<	<	1.00
11	<	<	1.00
7	<	<	.50
= 5	>	>	.50
> 9	>	>	1.00
12	>	>	1.00
10	>	>	1.00
14	>	>	1.00
16	>	>	1.00
15	>	>	1.00
18	>	>	1.00
17	>	>	1.00
		Average	.94

The above average represents the subject's consistency only for the number 4. This, when averaged with eighteen other averages, gives his general coefficient of consistency. The final coefficients, obtained in this manner, were as follows:

Givler	.92
Burt	.88
Marston	.88
Bridges	.87
Kellogg	.86
Miss Martin	.84
Dr. Langfeld	.78
Cutting	.76
Roback	.71

The classification of preferences according to their consonant and dissonant character shows an extreme preference for the dissonances on the part of Givler; Dr. Langfeld also shows a fairly distinct tendency of the same sort. The rest of the subjects prefer the consonances in varying degrees. The extremely "consonant" subjects are Marston, Miss Martin, Bridges, Kellogg; the other three—Burtt, Cutting and Roback—have the same general preference, but less marked. Ranking the subjects from the most "dissonant" to the most "consonant," we obtain the following order:

Givler
Dr. Langfeld
Roback
Cutting
Burtt
Kellogg
Bridges
Miss Martin
Marston.

FINAL EXPERIMENTS

The next problem was to find a method of recording any change in the degree of consonance of a given interval for the subject without suggesting to him the purpose of the experiment. Obviously little can be accomplished by merely playing a passage of intervals to him for five, ten or fifteen minutes, and then asking him to make a judgment whether the consonance of the interval has changed during that time. Not only is it impossible to eliminate a certain amount of suggestion in such a method, but it is hopeless to expect anything that approaches reliability in figures based on comparing pairs of impressions, one of which is pretty well obliterated at the time the judgment is made. We may find a clue to a better method by turning again for a moment to a consideration of the historical development of consonance. Musicians have always agreed[113] that the practical criterion of fully established consonance is the suitability of an interval in the final chord of a cadence. Now all the intervals that have so far met this requirement have fulfilled it only after having become the most acceptable intervals in parallel passages—parallel octaves among the Greeks, parallel fifths and fourths in the middle ages, parallel thirds in more modern times. The increase in acceptability as a parallel interval has been such an invariable feature of developing consonance that we may safely assume for our present purposes that the amount of decrease in dissonance may be measured in terms of this increase. But by the same token, further increase in fusion, once the interval has become consonant, will be marked by the decrease in its acceptability in consecutive parallels. That is to say, the interval which is just consonant is always at the height of its effectiveness for consecutive use. In becoming more consonant it becomes less available as a parallel interval.

We shall assume then as the measure of decreased dissonance the increase in the parallel value of an interval; and, as a measure of the increased fusion or synthesis of an interval already consonant, the decrease in parallel value. This is by no means an identification of consonance with the inherent pleasantness of an

[113] Parry, op. cit., 88.

interval, for we have to do here not with isolated intervals, but with consecutive parallels.

As before stated, the experiment is concerned directly with four intervals,—two consonances, the fifth and third; and two dissonances, the major and minor seventh. The problem is to find out whether the prolongation and repetition of these intervals produces anything which may be interpreted as a change in their degree of consonance; such a change, we have seen, can best be indicated by the amount of change in the acceptability of this interval as a parallel. How to determine the latter amount is our next question. The general method was that of paired comparison, with each judgment graded by the subject according to the degree of his preference. I began each hour of experiment by making out a table of graded comparisons of the four parallel intervals in question,—to which was added another, the minor ninth, in order to give a wider range of comparison. This table, which served as the standard for the day, was made up as follows: each interval, played consecutively in a passage of seven parallels, with c′ d′ e′ f′ e′ d′ c′ as the fundamentals, was compared with each other one played similarly. The subject was asked, in each case, not only to state his preference between the two passages, but also to grade the strength of his preference according to a scale A, B, C, D, E. A was to mean extremely strong preference, E extremely weak, while B, C, and D were intermediate grades. An example of the standard table follows:

Standard

	3	5	7	VII	9
3	×	3C	3B	3B	3A
5	3C	×	5B	5B	5A
7	3B	5A	×	7C	7D
VII	3B	5B	7D	×	VIIE
9	3A	5A	7C	VIIE	×

Miss Martin, Dec. 1, 1913

In all these tables, 3 means a passage of thirds; 5, one of fifths; 7, one of minor sevenths; VII, one of major sevenths; 9, one of minor ninths. The numbers to the left of the horizontal

columns indicate the interval given first in presenting a pair for comparison; those at the top of the vertical columns indicate the second interval in the pair. Thus parallel thirds, coming first, were in this table preferred to fifths by C, to minor sevenths by B, to major sevenths and to minor ninths by A. Parallel fifths, coming first, were inferior to thirds by C, better than minor sevenths by B, better than major sevenths by B, and better than minor ninths by A.

The interval under consideration for this particular day was the minor seventh; the method was that of prolongation. After having recorded the standard table, I proceeded to play a passage of parallel sevenths, sustaining each interval exactly one minute. I did this for five minutes, playing thus five intervals of a minor seventh. Immediately after this I asked for new judgments of preference, in which the comparison was made only between the minor sevenths and the other parallels. The results of these judgments, at the end of five minutes, appear in the "first five minute" table below.

Standard	3	5	7	VII	9
3	×	3C	3B	3B	3A
5	3C	×	5B	5B	5A
7	3B	5A	×	7C	7D
VII	3B	5B	7D	×	VIIE
9	3A	5A	7C	VIIE	×

TABLE TWO
(after five minutes)

	3	5	7	VII	9
3	×		3B		
5		×	5B		
7	3A	5C	×	7C	7B
VII			7D	×	×
9			7B		×

TABLE THREE
(after second five minutes)

	3	5	7	VII	9
3	×		3D		
5		×	7E		
7	3B	5C	×	7B	7A
VII			7B	×	×
9			7B		

When we compare the judgments of the sevenths in the standard table with those after five minutes of prolonging the interval, we find that it has lost one point to the thirds, has gained two from the fifth and three from the minor ninth. This gives it an increase in value of + 4 as compared with the standing of the seventh before prolongation. Repeating the same process for another five minutes, I obtained the results in Table Three. Here the minor seventh has gained two points on the third, six points on the fifth, three on the major seventh, and four on the minor ninth. Its value in this table is accordingly + 15 as compared with that of the standard table.

This process was repeated for a third and a fourth period of five minutes, sometimes for a fifth, but by this time the subjects expressed such general discomfort that it seemed hardly likely that the results could continue to have the same significance, especially as the hour was always nearly up at the end of the fourth trial. The use of a fifth period was therefore abandoned. The only other change in method which took place during the course of the experiments was in regard to the length of the prolongations. During the first few weeks of the experiments I used ten-minute periods, made up of five two-minute prolongations, and obtained the same type of results as later with the five-minute period, but the subjects indicated a far greater satisfaction in their attitude toward the five-minute length, and it was accordingly adhered to regularly after the first few weeks.

The method of repetition differed from that of prolongation

in that each period, three minutes in this case, was occupied not with sustaining intervals, but with playing repeatedly an entire melody in parallel thirds, fifths, minor or major sevenths, as the case might be. The melody used was, with the exception of one note, within the compass of a sixth, so that the same notes recurred with great frequency. Three minutes sufficed for four repetitions of the entire melody. The first phrase of the melody, eight notes, was used in making the comparison for the tables. The amount of positive or negative change was determined, as before, by counting the difference between A and B one point, between A and C two points, and so on. The difference between an E preference in favor of an interval and one against it was also counted one point.[1]

The general tables which follow give for each of the four intervals the average amount of change from the standard at the end of each successive period. In the few cases where the periods were longer than five minutes, the result was recorded in the "second five-minute" table. Thus in the case of the first subject, Bridges, the only prolongations of minor sevenths were in ten-minute periods. The figures in each of the five-minute spaces represent an average of from one to four experiments.

1. The subjects were instructed to limit their introspection to the graded expressions of likes and dislikes, unless something of unusual interest occurred. The danger of accompanying paired comparisons by abundant general introspection is shown very clearly in the experiments of T. H. Pear on the major and minor triad.[114] Of his five subjects, the three who introspected least were by far the most self-consistent. His most introspective subject had a coefficient of consistency of 27.5 on a scale where zero was perfect consistency, whereas the coefficient of the least introspective subject was 3.64. It seems almost inevitable that the subject, in attempting to give an account of how he arrives at his judgment, leads himself to judgments that would normally not be made.

[114] British Journal of Psych., 1911, p. 57.

TABLE X

Method of Prolongation

Subject	Interval	First 5 Minutes	Second 5 Minutes	Third 5 Minutes	Fourth 5 Minutes
B	Thirds	— 7	— 2	— 4	—10
Consistency .87	Fifths	— 4	+ 4	+ 9	+ 6
Dissonance	Minor sevenths		+14		+ 8
Rank 7	Major sevenths	— 1	+ 3	+ 2	+ 3
T	Thirds	+ 1	+ .5	+ .5	— 2
Consistency .88	Fifths	— .5	— 1.3	+ 1	0
Dissonance	Minor sevenths	+ 5	+ 5.7	+ 3	+ 5
Rank 5	Major sevenths	+ 3	+ 6.7	+ 5.5	+ 7.5
C	Thirds	+ 3	+ 2	+ 2	+ 3
Consistency .76	Fifths	+ 5	+ 3	— 1	0
Dissonance	Minor sevenths		+ 3		+ 5
Rank 4	Major sevenths	+ 5	+ 1	+ 4	+ 6
G	Thirds	—11	—19.7	—15	—15
Consistency .92	Fifths	+ 2	+ 6	+ 4	+ 2.5
Dissonance	Minor sevenths	+ 4	+ 9.3	+ 7	+22.2
Rank 1	Major sevenths	+ 8	+15.5	+ 8	+19.8
K	Thirds	— 4	— 4.9	— 3.2	— 3.8
Consistency .86	Fifths	— 2	— 3.1	— 1.3	— .5
Dissonance	Minor sevenths	— .8	— 2.3	+ 1.5	+ 3
Rank 6	Major sevenths	— 3.2	— 1.5	— 1.8	— 3.2
L	Thirds	— 4	— 5	— 6	— 6
Consistency .78	Fifths	— 4	— 2	— 4	— 8
Dissonance	Minor sevenths		+ 4		+ 4
Rank 2	Major sevenths	+ 2	+ 3	0	0
M	Thirds	— 5	— 9	— 9	—12
Consistency .84	Fifths	— 1	—12	— 5	+ 4
Dissonance	Minor sevenths	+ 4	+15	+10	+ 3
Rank 8	Major sevenths	+ 2	+ 4	+ 5	+ 3
S	Thirds	+ .5	+ .3	— 1.5	— 2.5
Consistency .88	Fifths	+ 1	+ .5	+ 1.5	+ 1.5
Dissonance	Minor sevenths	+ 6	+ 2.3	+10.5	+ 7.5
Rank 9	Major sevenths	+ 7	+ 4.5	— 1	+ 3.5
R	Thirds	— 6	— 9.3	— 7	— 5
Consistency .71	Fifths	+ 2	+ 3	— 1	+ 2
Dissonance	Minor sevenths	+ 2.5	— 1.5	0	+ .5
Rank 3	Major sevenths	+ 4	+ 4	+ 7	+ 7

TABLE XI

Method of Repetition

Subject	Interval	First 3 Minutes	Second 3 Minutes	Third 3 Minutes	Fourth 3 Minutes	Fifth 3 Minutes
B	Thirds	— 3	—13	— 3	— 6	— 6
Consistency .87	Fifths	— 6	— 9	—12.5	— 9.5	— 7
Dissonance	Minor sevenths	+12	+10	+ 9	+10	+12
Rank 7	Major sevenths	+ 4	+ 5	+ 5	+ 7	+ 4.5
T	Thirds	0	+ 1	+ 2	+ 3	+ 4
Consistency .88	Fifths	+ 1	+ 1	0	0	— 4
Dissonance	Minor sevenths	+ 4	+ 4	+10	+10	+10
Rank 5	Major sevenths	0	+ 5	+ 9	+10	+ 8
C	Thirds	0	— 3	— 2	— 2	— 1
Consistency .76	Fifths	— 6	— 8	— 5	— 5	— 3
Dissonance	Minor sevenths	0	+ 3	+ 1	+ 7	+ 6
Rank 4	Major sevenths	+ 2	+ 2	+ 1	+ 3	+ 7
G	Thirds	— 7	— 9	—14	—14	—17
Consistency .92	Fifths	+ 1	+ 1	— 5	0	
Dissonance	Minor sevenths	+12	+ 6	+ 2	0	0
Rank 1	Major sevenths	— 2	0	0	+ 2	+ 5
K	Thirds	+ 5	0	+ 1	— 2	— 1.5
Consistency .86	Fifths	+ 1.5	+ 1	+ 2	+ .5	+ 1
Dissonance	Minor sevenths	+ 2	— 6	+ 5	+ 4	
Rank 6	Major sevenths	— 4.5	— 5	— 6	— 6	— 5
L	Thirds	0	— 1	— 2	— 2	— 1
Consistency .78	Fifths	— 2	+ 6	+ 1	+ 1	— 1
Dissonance	Minor sevenths	+10	+ 7	+ 5	+ 2	+ 5
Rank 2	Major sevenths	+ 5	+ 6	+ 5	+ 3	+ 6
M	Thirds	—16	—17	—18	— 4	—14
Consistency .86	Fifths	— 3	— 2	— 2	— 1	— 1
Dissonance	Minor sevenths	+ 7	+13	+15	+12	+ 9
Rank 8	Major sevenths	+ 5	+ 1	+ 1	+ 4	+13

TABLE XII

SUMMARY OF AVERAGES

Method of Prolongation

Interval	First 5 Min	M.V.	Second 5 Min.	M.V.	Third 5 Min.	M.V.	Fourth 5 Min.	M.V.
Thirds	— 2.9	3.6	— 6.2	5.3	— 4.0	3.9	— 6.6	4.4
Fifths	— .3	2.4	— .5	3.9	+ .4	4.2	+ .9	2.8
Minor sevenths	+ 3.0	1.9	+ 4.0	4.7	+ 5.0	3.8	+ 8.5	5.3
Major sevenths	+ 2.1	2.8	+ 4.3	2.9	+ 2.5	3.1	+ 7.5	5.0

TABLE XIII

Method of Repetition

Interval	First 3 Min.	M.V.	Second 3 Min.	M.V.	Third 3 Min.	M.V.	Fourth 3 Min.	M.V.	Fifth 3 Min.	M.V.
Thirds	— 3.0	5.7	— 6.0	6.0	— 5.1	6.2	— 3.9	3.7	— 5.2	6.1
Fifths	— 1.9	2.6	— 1.4	4.2	— 3.0	4.1	— 2.0	3.0	— 2.5	2.2
Minor sevenths	+ 6.7	4.0	+ 5.3	4.2	+ 6.7	3.9	+ 6.4	3.8	+ 6.8	3.4
Major sevenths	+ 1.4	3.2	+ 2.0	2.7	+ 2.1	3.6	+ 3.3	3.2	+ 5.3	3.5

The above results are represented graphically in the tables which follow. The last of these tables, number XXII, is made from the statistics of C. W. Valentine[115] concerning the ontogenetic development of interval preferences. Reference is made to it later in the discussion.

INTERPRETATION OF RESULTS

It will be seen at a glance that whether we use the method of prolongation or of repetition, certain very characteristic tendencies appear for each of the four intervals. The third loses rapidly, the minor seventh gains equally rapidly, the fifth maintains a fairly constant level, the major seventh rises in value, but less rapidly than the minor seventh. It cannot be said that these changes are merely cases of a general adaptation which levels the distinction of pleasant and unpleasant. If this were true we should expect the greatest positive values in the case of the major seventh parallels, which are distinctly more disagreeable than those of the minor seventh. But the minor

[115] C. W. Valentine, Internal Preferences in Elementary School Children. Brit. Journ. of Psych., Oct. 1913, 190 ff.

seventh actually has an average rise of 5.8 points as against 3.4 for the major seventh. Moreover, the lowest individual average value of the major sevenths,—3.1, was obtained in the case of a very "consonant" subject, Kellogg, who expressed the strongest distaste for them at the outset. And, further, the highest average positive value for the same interval, + 10.0, was obtained from the most "dissonant" subject, Givler, whose persistent bias in that direction we saw in the preliminary experiments on resolutions. Any argument to the effect that the processes which we have been describing merely tend to reduce affective differences is set at naught by the fact that there were actually 132 cases in which the minor seventh, after being judged inferior to the fifths or thirds in the standard table, was judged better in the prolongation or repetition tables. Thus Givler, after four five-minute prolongations of the minor seventh, preferred such parallels to any others; and remarked that to him they then seemed less like dissonances than like very full interesting consonances. His is, of course, an extreme case, but extreme only in exhibiting more of the same tendencies which others manifest to a less degree.

Clearly the particular form of adaptation manifested here is most readily accounted for by the interpretation that a dissonance, when prolonged, becomes more suited for consecutive use; that is to say, more perfectly synthesized, in short, more nearly consonant. And since the region of highest affective value for an interval is the barely consonant region, we may expect the most rapid increase of value in that dissonance which is nearest this region; namely, the minor seventh. We actually find this to be the case almost without exception. We further expect to find the most rapid decline in the case of prolonged thirds, since they have reached their maximum value on becoming just consonant. This also is obviously indicated in the results. The fifth, being a more established consonance than the third, and therefore nearer its limit of synthesis, we should expect to show a lower initial value than the third, but a correspondingly greater stability in resisting the effects of repeated hearing. This is borne out by the results. When prolonged, the fifth changes

almost not at all; when repeated, it declines, but much more slowly than the third. If this experiment had been made on a ninth century subject, we might have expected a very rapid decline of the fifth and rise of the third.

The fifths give in one or two cases certain curious results which call for especial consideration. The highest values regularly assigned to them in the standard tables were given by Givler and Kellogg, both violinists. Kellogg ranked them very nearly equal to the thirds at the outset, and gave a slight positive change after repetitions, a slight negative change after prolongations. There was nothing unusual in this except in the high initial value; but Givler always preferred the fifths to the thirds at the outset, and liked them still better after prolongation! His average prolongation value for fifths was + 3.4. When asked to introspect his attitude toward them, he stated that to him they seemed to have more masculine quality than the thirds; also that he felt less jar of movement in a passage of fifths than in one of thirds. Further, the fifth seemed so unified and self-sufficient that he did not think of it as empty.

This suggests very strongly the existence of a second stage in the development of an interval after its consonance has been well established, a stage in which it is apprehended by the hearer less as an interval and more as a reinforced unison. In this new capacity it is capable of taking on a new lease of interest. Further experiments will be necessary in order to determine the existence of such a secondary transition from empty interval to full unison. For the present the only evidence at hand is the comparison of the fifths with the octave. Statistics by C. W. Valentine[115a] on 62 men and 84 women indicate that in immediate pleasantness the octave is ranked by the men second among all musical intervals, preceded only by the major third; women rank it fourth, preceded only by the thirds and major sixth. In both cases it has a distinctly better value than the fifth, although it is distinctly the more consonant of the two. The stage of consonance which lies between the fifth and the octave thus appears to be marked at some point by an increase in affective

[115a] Op. cit.

value. A fairly adequate idea of the changes which take place in the affective value of the octave and fifth between childhood and maturity may be obtained by examining in Table XXVII the graphic representation of some of Valentine's statistics. He obtained two widely different groups of results, one from elementary school children, and the other from girls in a preparatory school. His object was to grade the intensity of likes and dislikes for all the musical intervals at the different ages between six and fourteen. The judgments given by his elementary school children are too chaotic to offer any sort of conclusive evidence. These children of the ages of six and seven "liked" all the intervals, "liked" them all very much the same, but the major seventh was preferred to the major sixth! Either the real facts were obscured by the inability of the subjects to conform to the simple requirements made of them, or else their likings were for mere noise as such. The second group, the girls in the preparatory school, were apparently in every way more alert than the first. Valentine says of them,[116] These children took a very keen interest in the tests, and most of them, even the very youngest, seemed very decided in their judgments." It sems therefore probable that the results given by these girls between the ages of nine and fourteen will represent to a certain degree the affective changes that take place during that period. His results for these years, combined with the statistics on adults, are represented graphically in the table. They show a general rise of the minor and major seventh, and a general decline of the major third from the age of nine to maturity. The fifths, with the exception of a marked fluctuation at the age of twelve, shows a slow and continuous increase up to maturity. The octave shows a marked rise between the ages of nine and thirteen, followed by a decline from then until maturity. These results offer in general a significant parallel to my prolongation tables, and in addition point to the existence of the particular kind of development in the fifth and octave which we have found suggested by my results in one subject. That is, the increase of the value of the octave in children, and of that of the fifth in my violinist

[116] Op. cit., 206.

subject, both alike indicate that when the unity of the developed consonance has reached a certain completeness, its effect may become enhanced by its increased dynamic value. The octave, which doubles the melody, and the fifths, used in organ mixtures, have acquired a new kind of interest in their capacity of re-enforcing the fundamentals. But let the octave or fifth be apprehended as an adhesion of two separate tones, as in the consecutive octaves and fifths of four part harmony, and the result is a most disagreeable barrenness.

CHAPTER VI

Conclusion

The facts obtained in the foregoing experiment, as well as those of musical history, favor the assumption that the degree of consonance increases as a result of the frequency with which an interval is heard. Moreover, each interval, in its development from dissonance to a high degree of consonance, undergoes a characteristic affective development corresponding to the different stages in its course. There is a continuous rise in affective value as we pass from the extreme to the slight dissonance; the bare consonance possesses the highest pleasantness of all intervals, but increasing consonance means for it a marked affective decline, until we reach the point where the interval gives the effect of a true unison, intensified dynamically; at this point follows a second affective rise, but by no means so great as that which marks the transition from dissonance to consonance. It goes without saying that the inherent affective quality of an interval may be greatly changed by the presence of such contributory factors as enter into any system of harmonic relations but this fact does not alter the fundamental fact that each consonance degree has its characteristic affective value.

The phenomenon of consonance, if the theory here advanced is right, is a special case of the adjustment of the inner to the outer relations. The nervous system, by a form of activity that tends with each repetition to become more simple and economical, gradually affects the synthesis of more complex physical relations. The affective aspect of the various stages of this process becomes more explicable when we consider that consciousness is most vividly present where new adjustments are being made. Where a synthesis has been accomplished so often as to be affected with ease, as in the case of the fifth, the output of consciousness is low as compared with that involved in synthesizing the third, where the accomplishment is relatively difficult. Now according

to Professor Fite,[117] whose view I accept, the whole question of pleasure-pain is to be referred to the same conflicts which occasion consciousness. To quote from him: "Not only is conflict a condition of consciousness, but it is especially a condition of pleasure-pain. . . . Pleasure is succeeding, pain is failing in the process of resolving a conflict."[118] Using as an illustration a game of tennis, or of chess, he says: "All the feeling lies between two points—between that at which your opponent becomes strong enough to offer appreciable resistance and that at which he becomes so strong that any effort on your part is futile. If your opponent is too weak, struggle is unnecessary; if he is too strong, struggle is useless."[119] In another passage he says to the same effect,—"There is certainly a more intense pleasure in removing a stubborn obstacle than a pliant one. Pleasure depends not merely upon the prosperity of our undertakings, but upon the size of them, as estimated by the difficulties presented."[120] This last sentence presents, I think, exactly the point of view which we must carry to the consideration of the varying pleasurability of various intervals. It is thus that we can understand why different periods of history, different peoples of the same period of history, and the same individual at different periods of his own development can give such different accounts of the same interval. We may say that the fifth was the most pleasurable of all intervals for the ninth century hearer because, in the conflict which his synthesizing mind waged against the complexity of physical relations, he was just able to succeed with the 2:3 ratio. The third, 4:5, was slightly too difficult, but not so much as to discourage further hearing, especially if it could be immediately followed by a fifth. With a further advance, due to repeated hearing, the fifth becomes a relatively uninteresting affair, whereas the third, which can just be unified, acquires a tremendous vogue. Hence the amazing fondness for thirds at the time of Monteverde, hence the high value of the third for the young

[117] W. Fite, The Place of Pleasure and Pain in the Functional Psychology. Psych. Rev. X, 1903, 633-644.

[118] Op. cit., 638.

[119] Op. cit., 637.

[120] Op. cit., 638.

child of to-day, hence the rapid decline of the third when heard with great frequency by the adult to-day. The minor seventh, we may suppose, was almost discouragingly complex for the hearer in the tenth century,—as for Valentine's nine-year-old girls who gave it a value of — 44 as compared with + 52 for the major third. But with more and more frequent hearing it has been attacked with nearer success. Its rapid gain in my experiments is most clearly understood if we consider the 5 : 9 ratio as a tonal adjustment not quite completely successful. That it will later rank among the consonances we can scarcely doubt, if past successes are any index to the future. When it does become so, it will be the most pleasurable of all intervals, since its unification will make more demands on the mind than that of any of the other consonances. Exactly the same is to be said for the major seventh. At first it is disheartening in the opposition it offers to synthesizing activity, but the change that takes place with repeated hearing is, as a rule, definitely positive. Certainly it will take thousands, perhaps hundreds of thousands, of hearings to bring it about that its impression will be distinctly less dissonant than at present, but this is no reason for assuming that it will mark any exception to the law of consonance evolution.

What limits may we expect to the type of development here set forth? This is in effect the question asked in the introduction of the discussion. An answer is suggested by the following passage from Professor Fite: "Where an equilibrium has been reached it is certain to be disturbed by the coming to consciousness of further capacities which call for further realization. . . . The conflict is brought about by the increasing demands of the life purpose as opposed to the conditions that stand in the way of its realization, and the resolution of the conflict means that the obstructions are either removed or discovered to be definitely insurmountable."[121] Applying the same principle to that form of equilibrium which is experienced as consonance, we may say that there is no reason to expect that any one consonance-dissonance division will ever be ultimate. As soon as our tonal consciousness succeeds in the mastery of certain ratios, it tends

[121] Op. cit., 640.

necessarily to pass on to those that are a little more complex. The reduction of old consonances to emptiness, the establishment of new dissonances as consonances, this seems to be the typical form of a development to which it is impossible to set any limit. To be sure, there are certain tonal combinations which, to our present consciousness, mean only insurmountable difficulty. For example, if all the notes on a piano be struck at once, the effect is not even one of unpleasantness; it is musically insignificant. The case is comparable to that described by Professor Fite in which the resistance to be overcome is so strong that any effort is futile. This is an altogether different kind of experience from that of the harsh dissonances, such as the major seventh, for in experiencing the latter the hearer pits himself against them; his mind tries to synthesize them; he fails, and experiences excruciating displeasure. But as these extremely harsh intervals become gradually more acceptable, we must suppose that more and more of what now passes for chaotic jumble will become significant,—always painfully significant at first; and the direction of this progress will be from the more simple to the more complex mathematical ratios.

There remains the question whether the practical limits set by a particular system of harmony may not cut short an otherwise limitless progress. Stumpf touches on this question, in his article entitled "Konsonanz und Konkordanz."[122] He maintains here, as elsewhere, that the difference between a consonant and dissonant interval is a difference only of degree, and he admits, on different grounds from those which I have set forth, the possibility of an indefinite increase in the number of intervals that will be included among the consonances.[123] He accordingly atempts to explain the specific opposition of consonant and dissonant combinations, not as belonging to the common fundamentals of music, but only to the developed products of the harmonic epoch. The distinction of consonance and dissonance, which he limits in application to intervals, is gradual and susceptible to continuous change; but the distinction of concord and dis-

[122] Zeitschrift für Psychologie, Vol. 58.
[123] Op. cit., 341.

cord, which he applies to chords formed according to a particular structure principle, is one that will continue unaffected by the gradually enlarged scope of consonant intervals. Thus,—"Konsonanz und Dissonanz sind nur graduell verschieden, und es kann der Grenzstrich an verschiedenen Punkten der Riehe gelegt werden. Dagegen Konkordanz und Diskondanz sind spezifisch verschieden, und es giebt keinen Ubergang und keine Zwischenstufe, sondern nur ein Entweder-Oder."[124]

The structure principle according to which our present system of concord has developed is, says Stumpf, that of selecting as a fundamental chord basis the greatest possible number of consonant intervals within the octave, taking them progressively according to their grades of consonance, from the stronger to the weaker degrees. Thus in the octave c-c′ we proceed from c first to the most consonant interval, the fifth, g; then to the third, e or e♭. We thus obtain as fundamental elements the triads c-e-g, and c-e♭-g. By repeating the same process with the two notes most consonant with c, namely g and f, we obtain the additional triads, g-b-d, and f-a-c. With these we have the material for the whole of our present scale. Secondary triads are now formed on every note on the scale, and thus furnish the chromatic elements with which the concordant triads can be rationally altered. A concord is a pure triad form; that is, a tonal construction according to the principle of the maximal number of tones within an octave that can be consonant with the fundamental and with each other, when the consonances are arranged in order from the stronger to the weaker. A discord is a rationally altered concord; that is, a tonal construction in which a triad, by the substitution or addition of chromatic elements, thus progresses more necessarily and fluently to another related triad.

The above scheme, which is worked out with great consistency by its author, offers a solution to many theoretical difficulties, especially to the question why a consonant interval may sound either concordant or discordant according to its musical context. It is, in fact, the only attempt up to the present which adequately explains the extent to which our pleasure and displeasure can

[124] Op. cit., 341.

emancipate themselves from the merely sensory factors in musical combinations. But is not clear that even this well grounded opposition of concord and discord is one whose foundation elements will not undergo a further evolution. It is arbitrary to assume that the maximal number of consonances available for the construction of concords will always be the particular number at present in use. Stumpf is at considerable pains to justify his exclusion of the natural seventh, 4 : 7, from his original interval elements. He gives two arguments for building his system on the triad 4 : 5 : 6, rather than on a chord of four notes, 4 : 5 : 6 : 7. First, the chord 4 : 5 : 6 : 7, when played with the third a minor, would give a noticeable dissonance, 20 : 24 : 30 : 35, since the fifth 24 : 35 varies too widely from the pure fifth 24 : 36. Second, the modern scale, formed from triads of the more perfect consonances, has already established as its seventh the dissonant 5 : 9. The intrusion of the 4 : 7 would only cause disagreeable confusion of the 5 : 9 and 4 : 7; and, since the 5 : 9 already has the right of way, the 4 : 7 is rejected altogether.

But what, we may ask, is to be expected when the 5 : 9 also becomes a consonance? The argument from the necessary dualism of major and minor will no longer hold good, since with the 5 : 9 as seventh the minor chord c-e♭-g-b♭ offers even less difficulty than the major. In fact, the same chord, a-c-e-g, is treated almost as a concord by Leoncavallo in "Pagliacci." Likewise the argument from the confusion of sevenths will cease to obtain, since the new consonance in question will be an element already contained in the scale. If our system of harmony is to continue to be as rational as Stumpf makes it out to be at present, then the advent of the 5 : 9 as a universally accepted consonance will necessitate the reconstruction of the whole system of harmony on the basis of a chord of four instead of the triad 4 : 5 : 6.

We must conclude, then, that the present opposition of concord and discord is alterable for the same reasons as those that obtain for the opposition of consonance and dissonance. The only difference is that the latter rests on isolated sensory experience whereas the former is an antagonism which has been organized into a complete system. It will, therefore, offer a tremendous

resistance to anything that makes for upheaval. But, if the point of view that has been maintained here is a sound one, we must expect that our whole system of harmony will gradually come to reflect whatever changes occur in the consonance degrees of its constituent intervals; and this latter type of change, we have seen, is one to which no limit can be set.

TABLE XIV

SUBJECT B

CONSISTENCY .87

DISSONANCE RANK 7

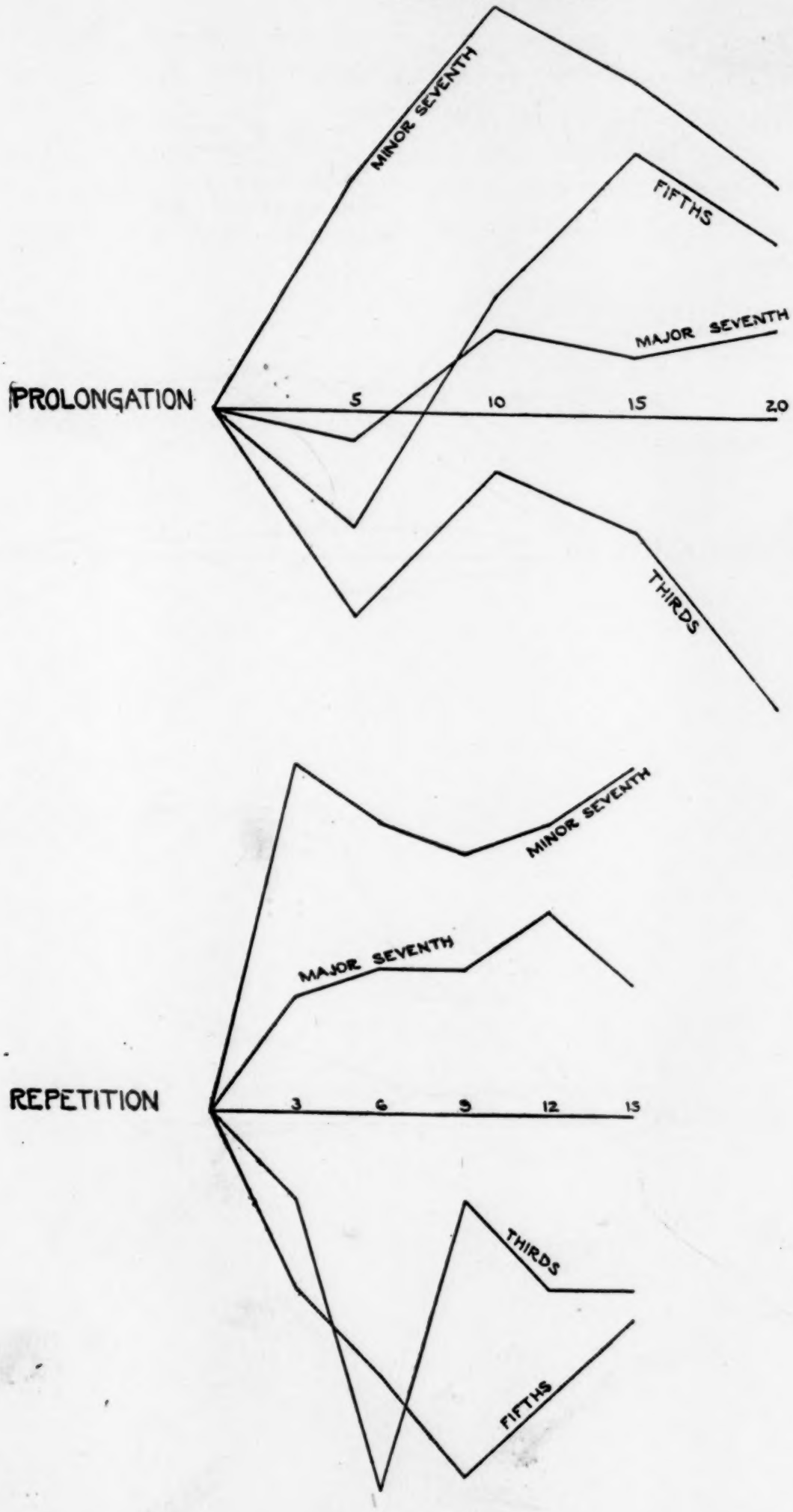
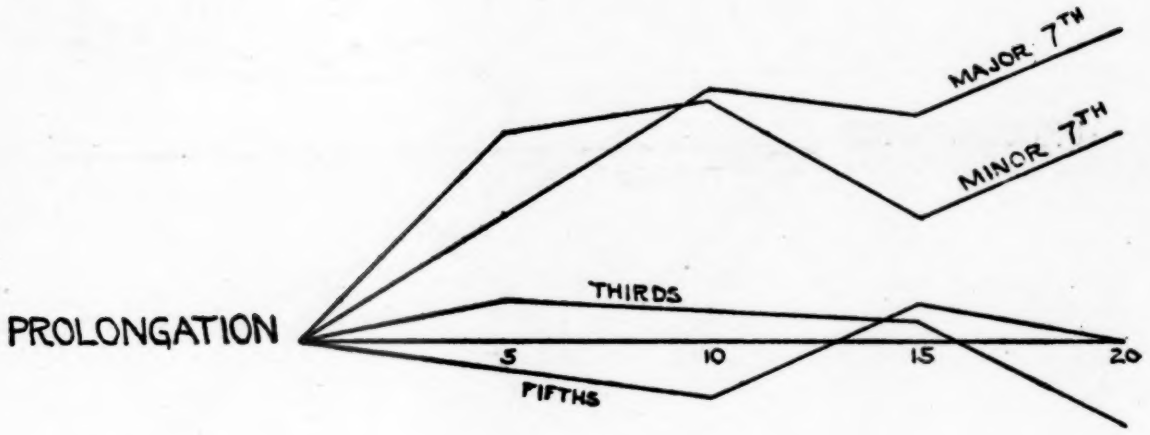


TABLE XV
SUBJECT T
CONSISTENCY .88
DISSONANCE RANK 5



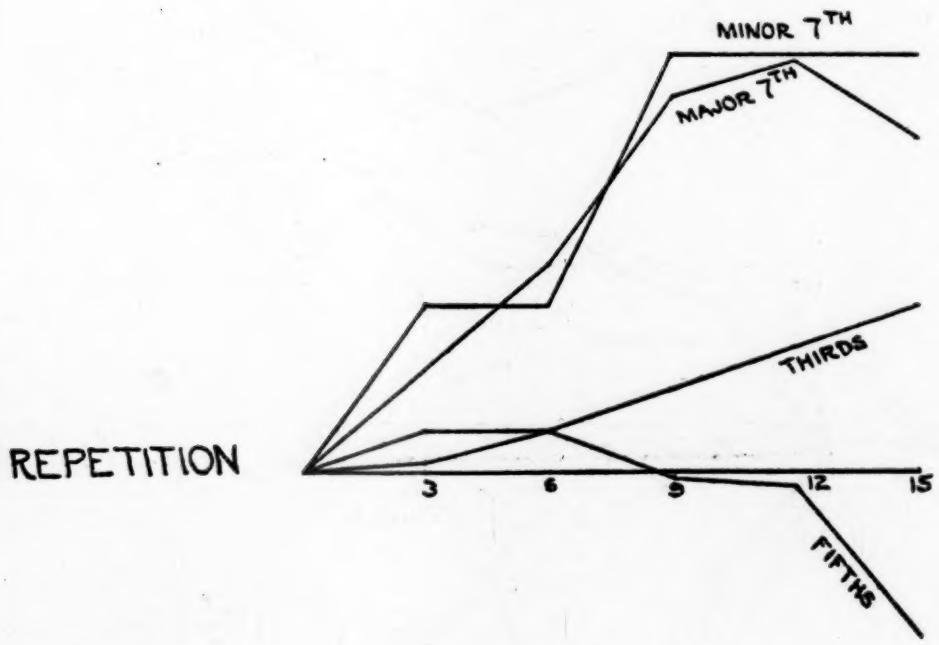
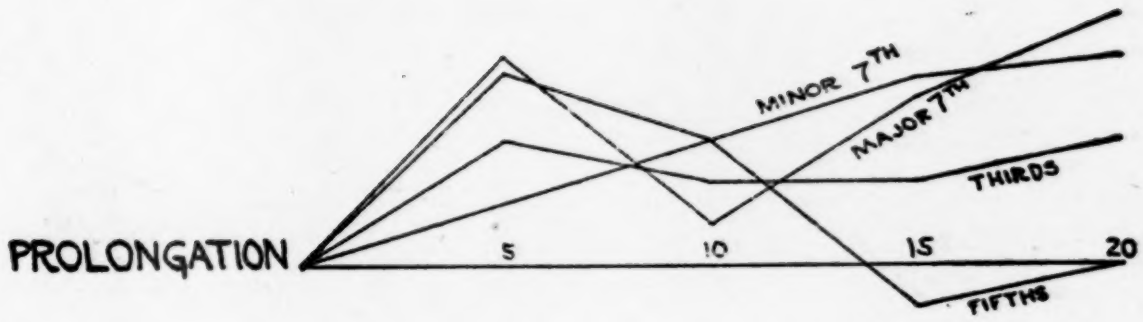


TABLE XVI
SUBJECT C
CONSISTENCY .76
DISSONANCE RANK 4



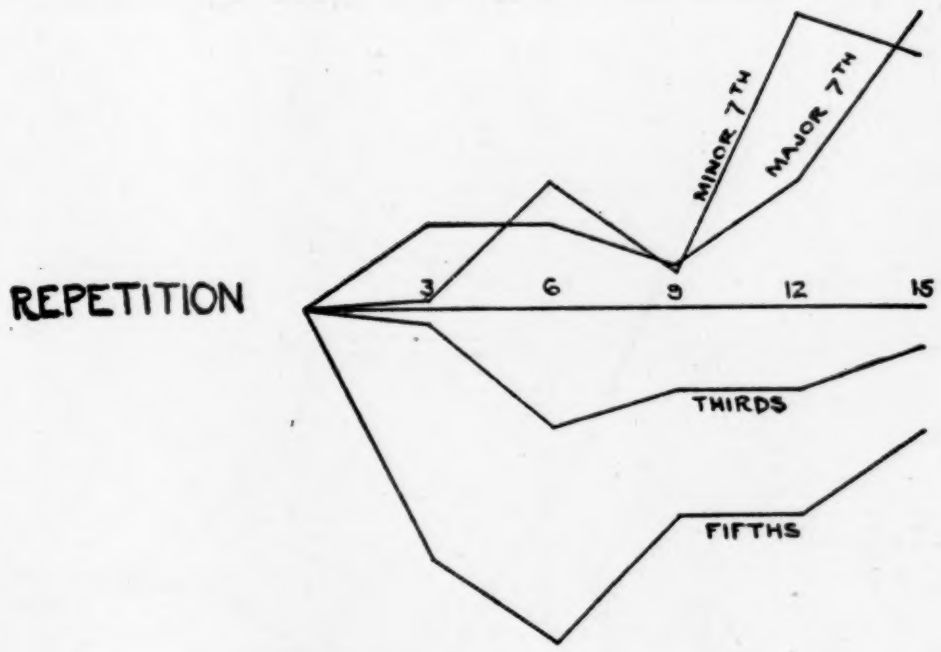


TABLE XVII
SUBJECT G
CONSISTENCY .92
DISSONANCE RANK 1

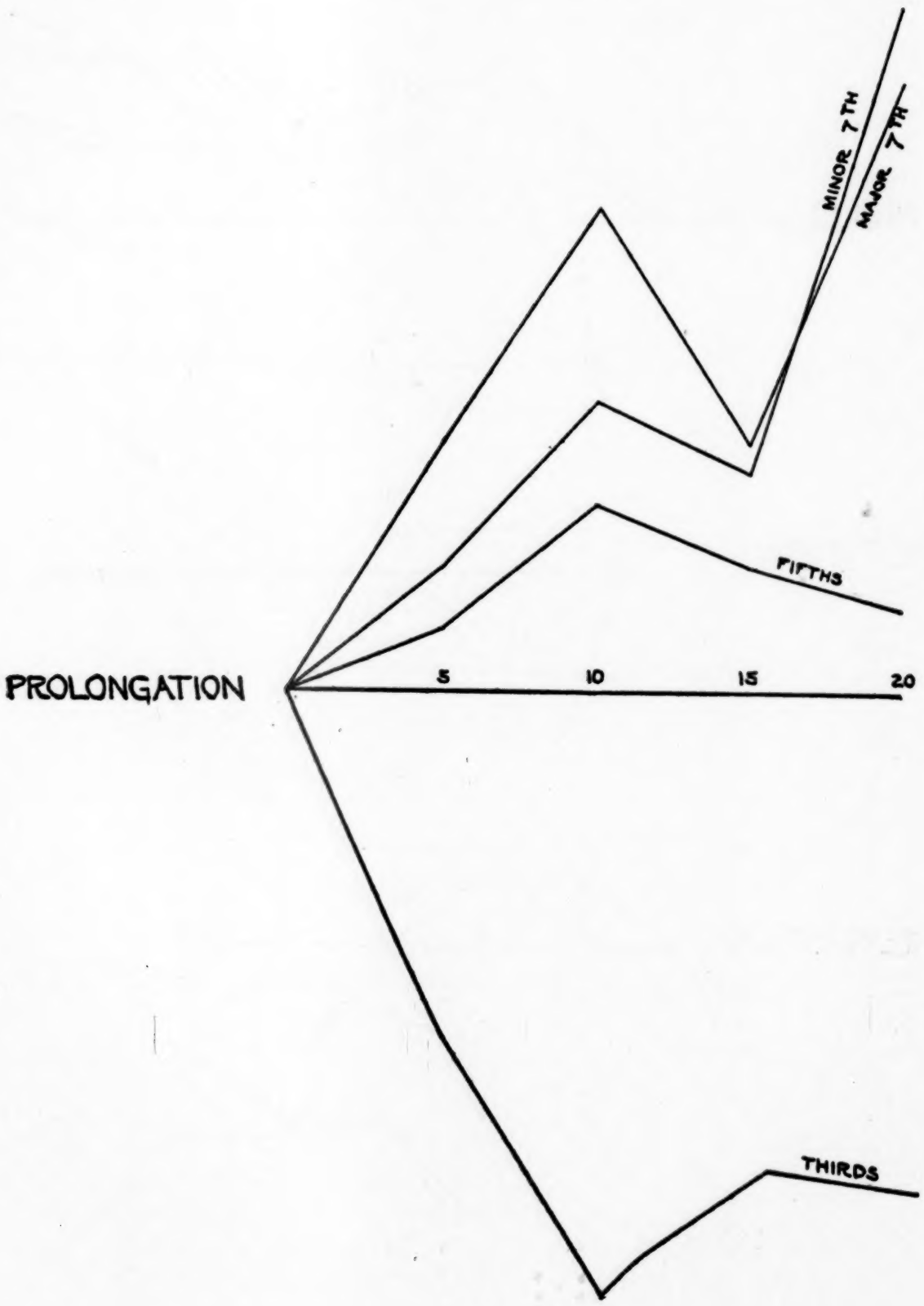


TABLE XVIII
SUBJECT G
CONSISTENCY .92
DISSONANCE RANK 1

REPETITION

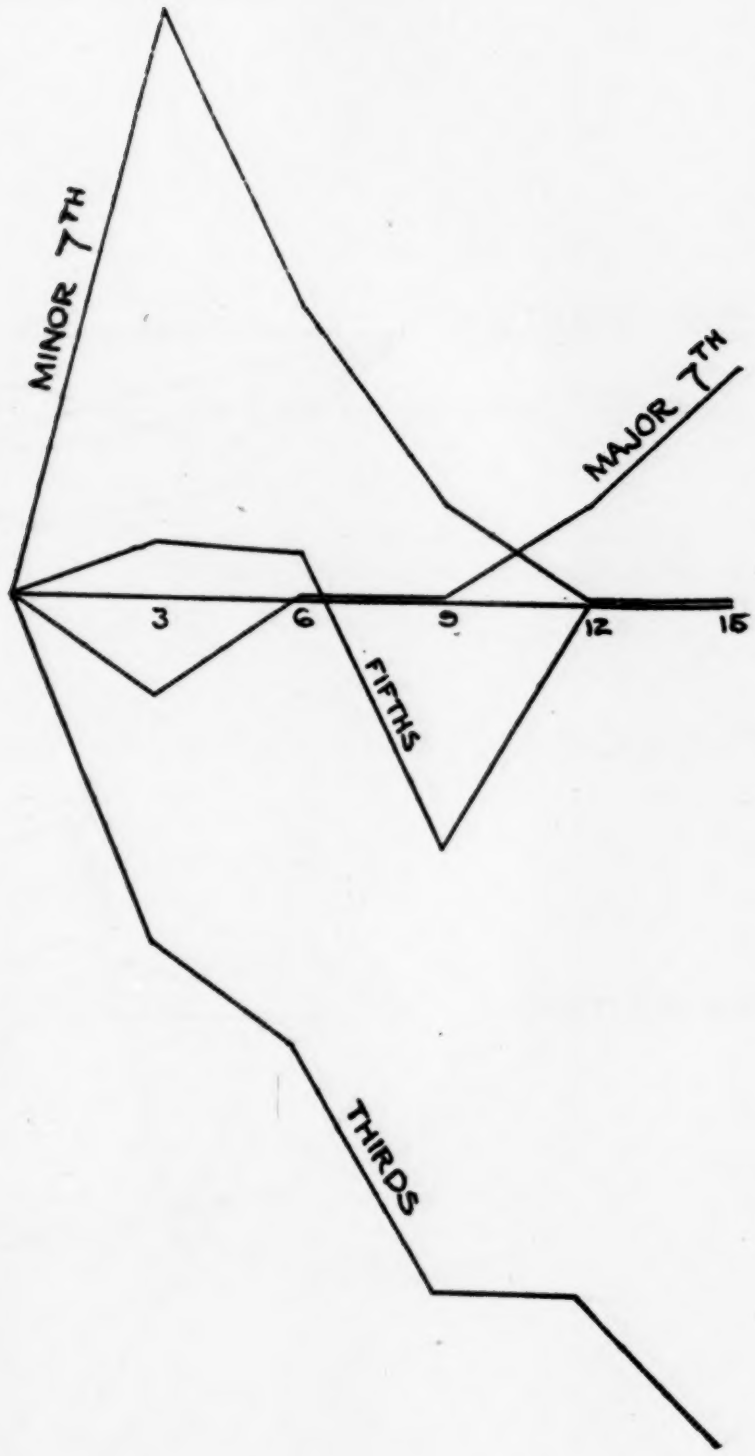
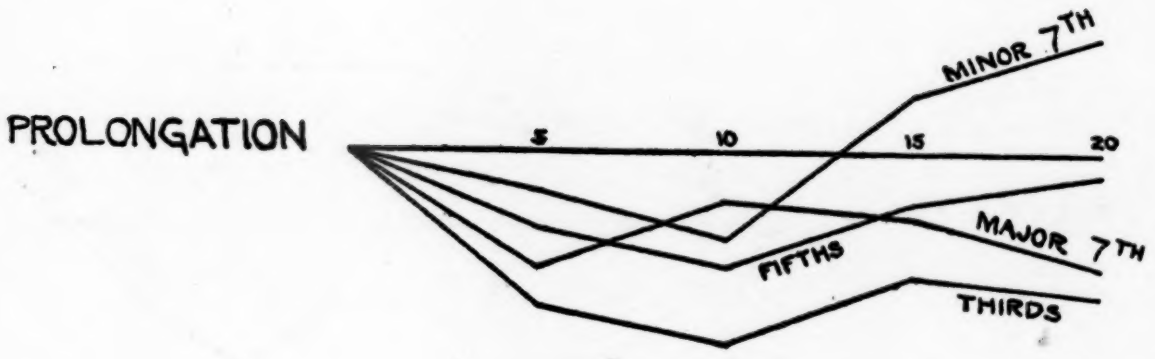


TABLE XIX
SUBJECT K

CONSISTENCY .86
DISSONANCE RANK 6



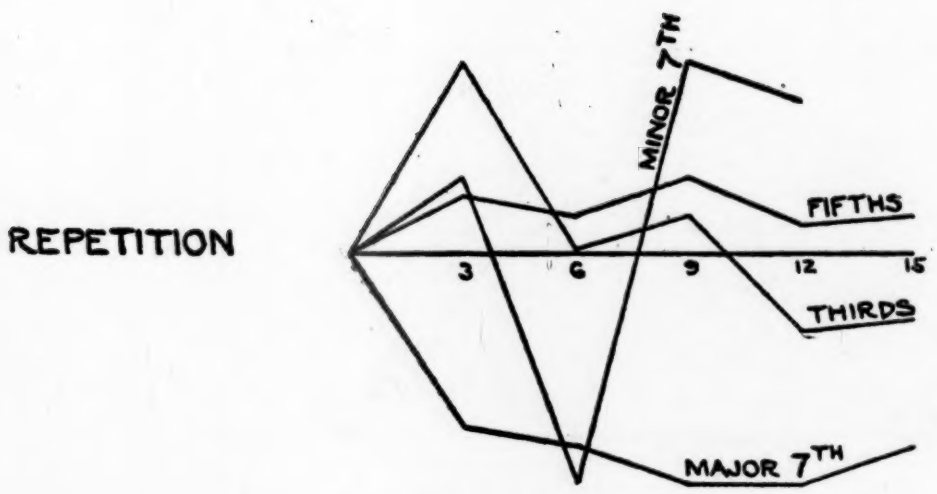
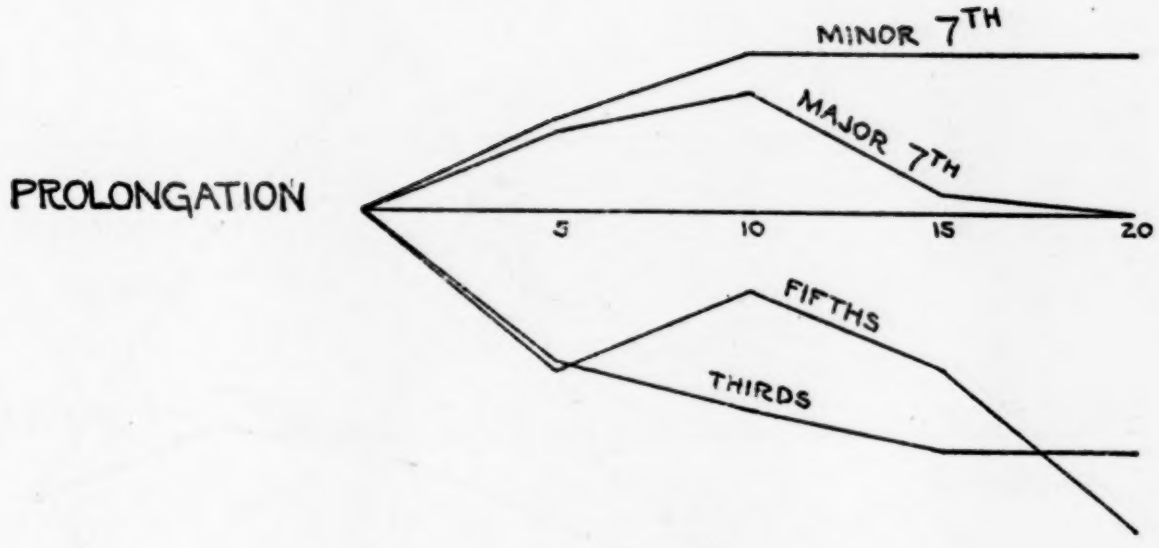


TABLE XX
SUBJECT L
CONSISTENCY .78
DISSONANCE RANK 2.



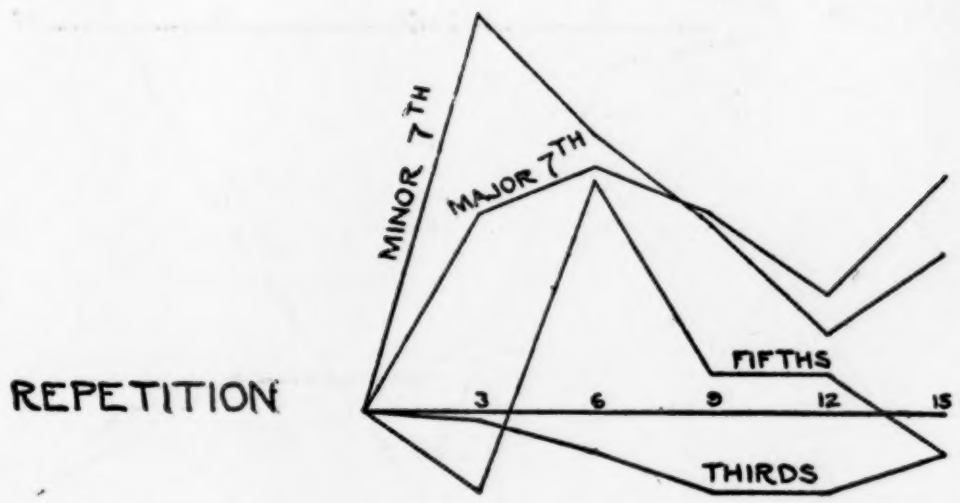


TABLE XXI
SUBJECT M
CONSISTENCY .84
DISSONANCE RANK 8

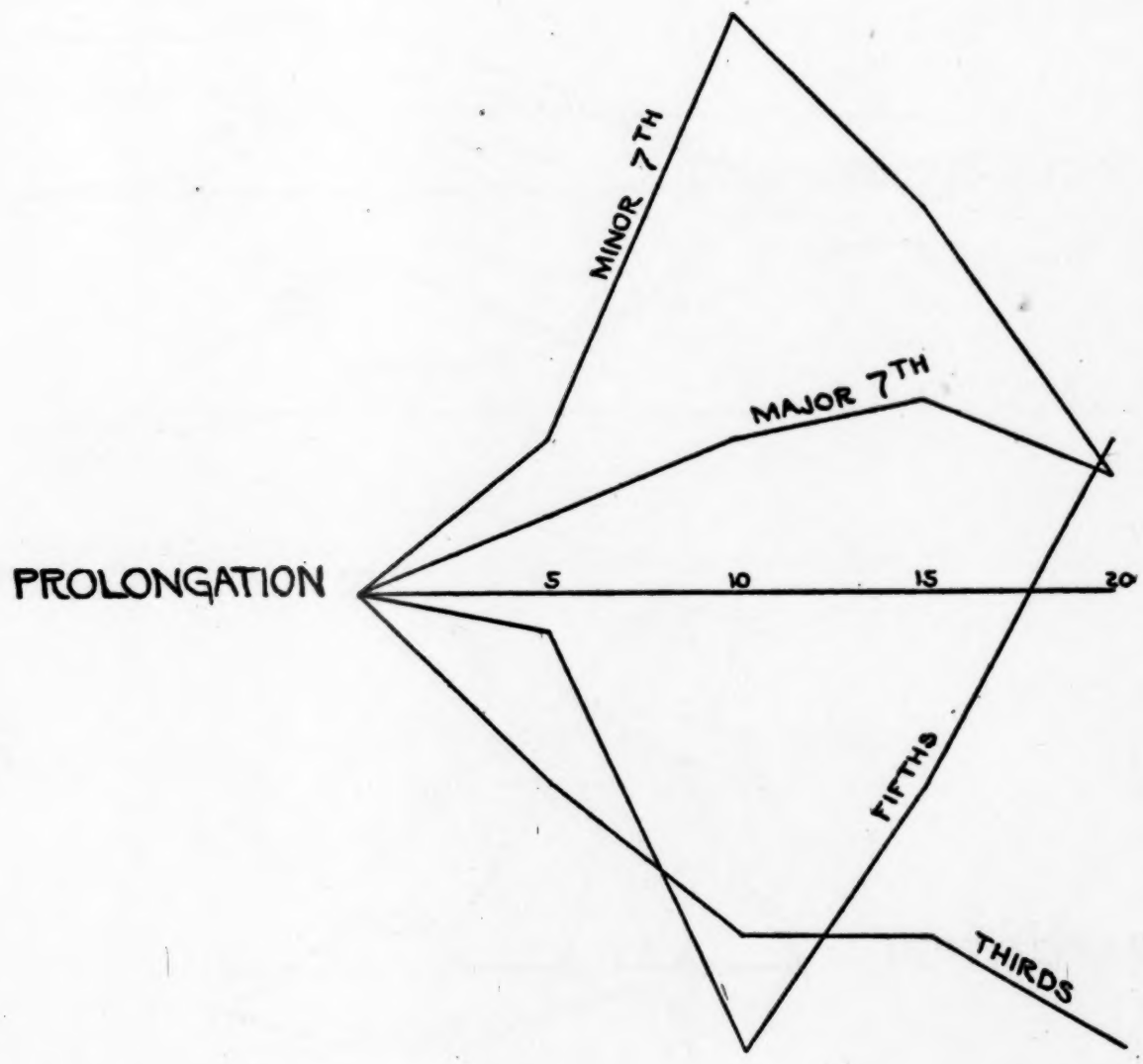


TABLE XXII
SUBJECT M
CONSISTENCY .84
DISSONANCE RANK 8

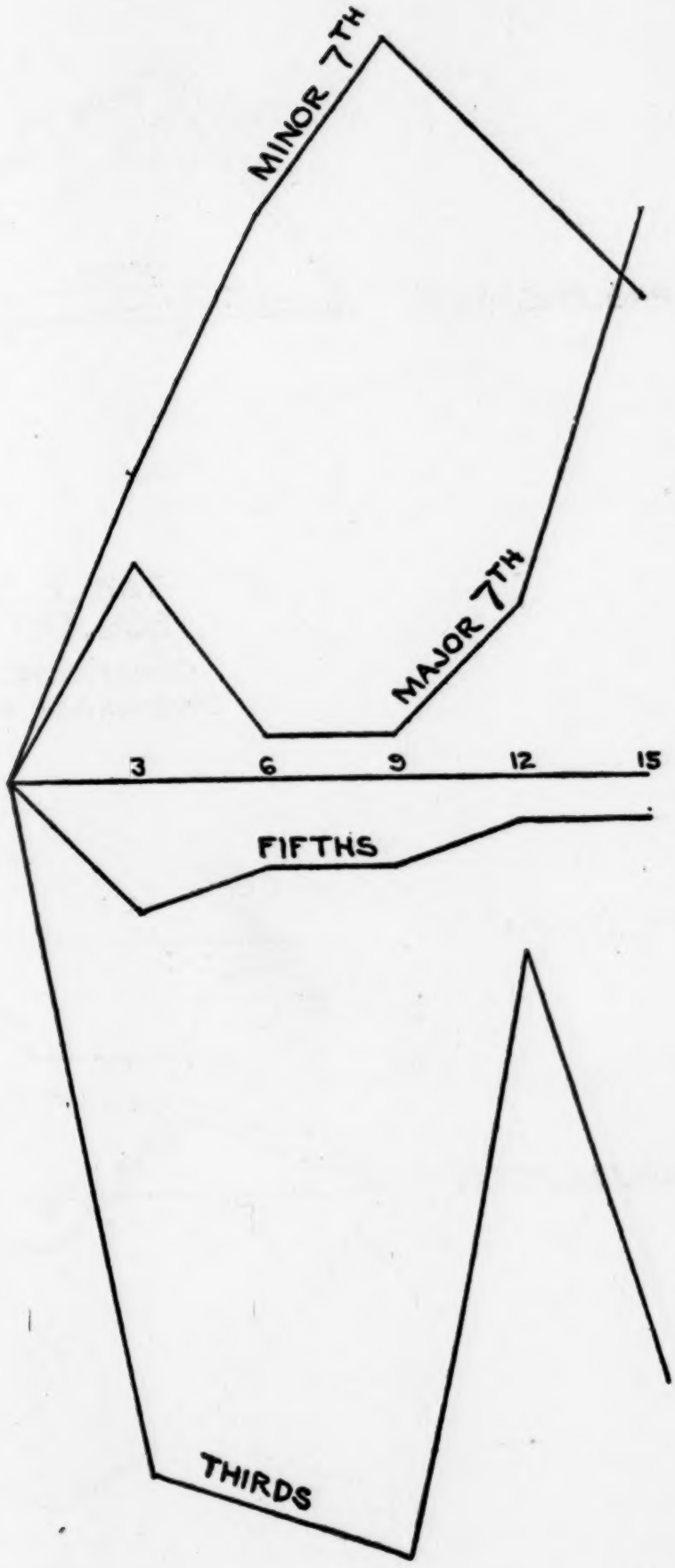


TABLE XXIII
SUBJECT S
CONSISTENCY .88
DISSONANCE RANK 9

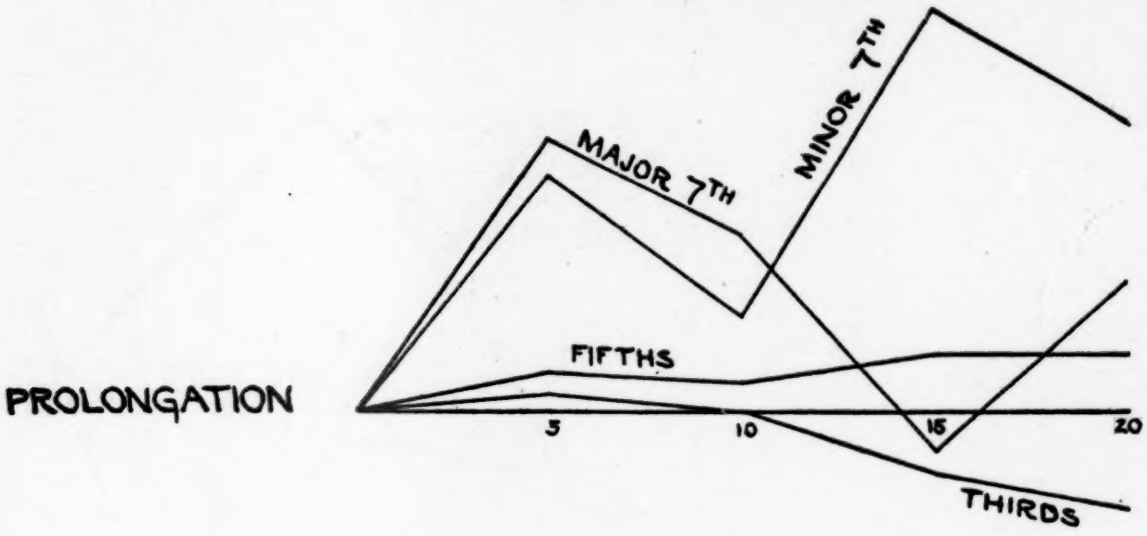


TABLE XXIV
SUBJECT R
CONSISTENCY 71
DISSONANCE RANK 3

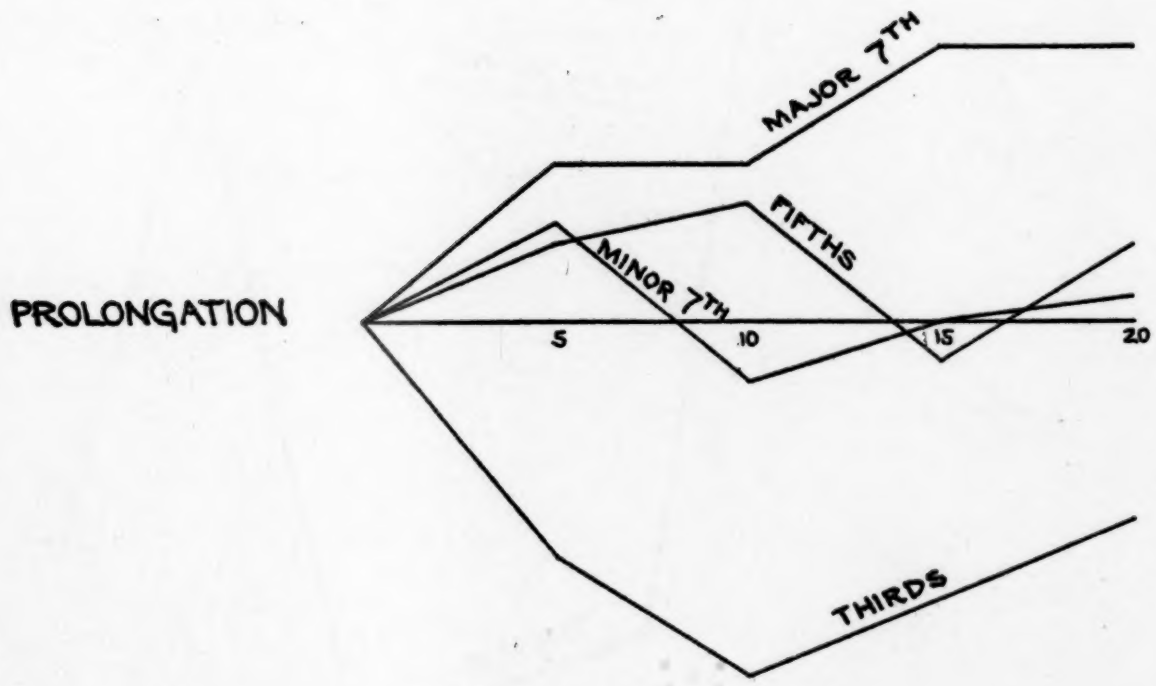
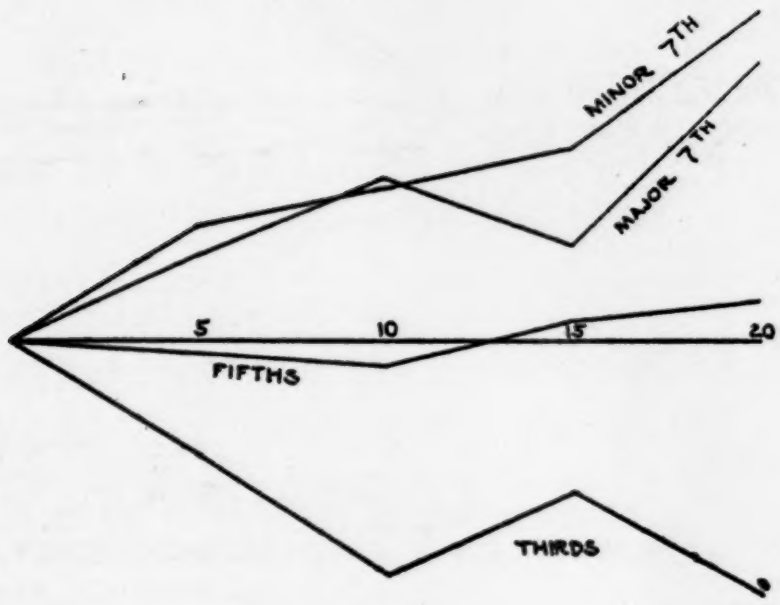


TABLE XXV
AVERAGE OF ALL SUBJECTS

PROLONGATION



REPETITION

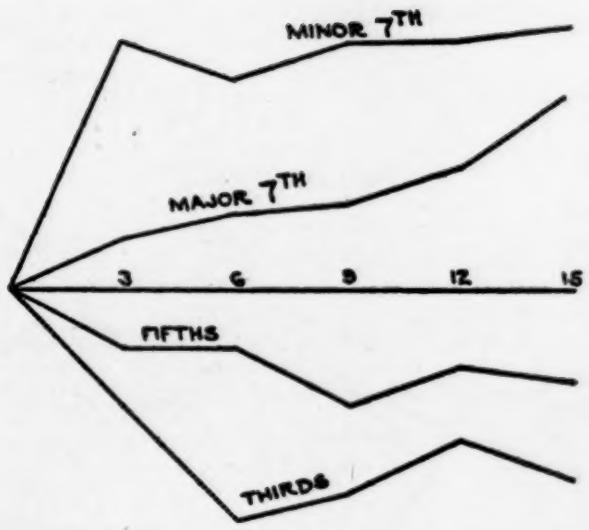


TABLE XXVI

AVERAGE OF SEVEN MOST CONSISTENT SUBJECTS

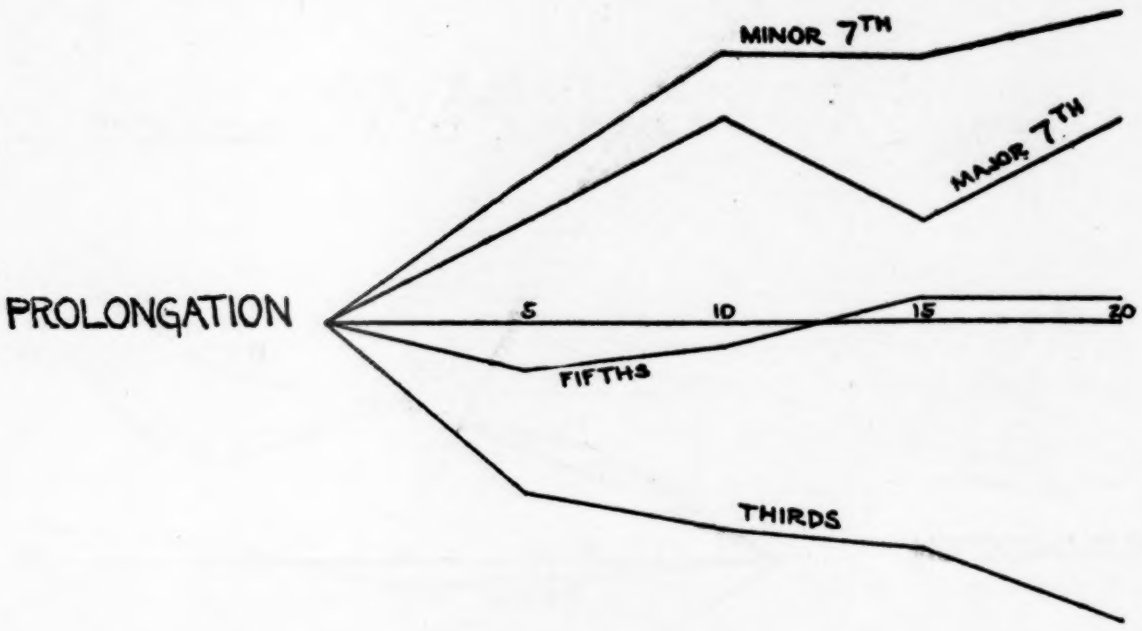
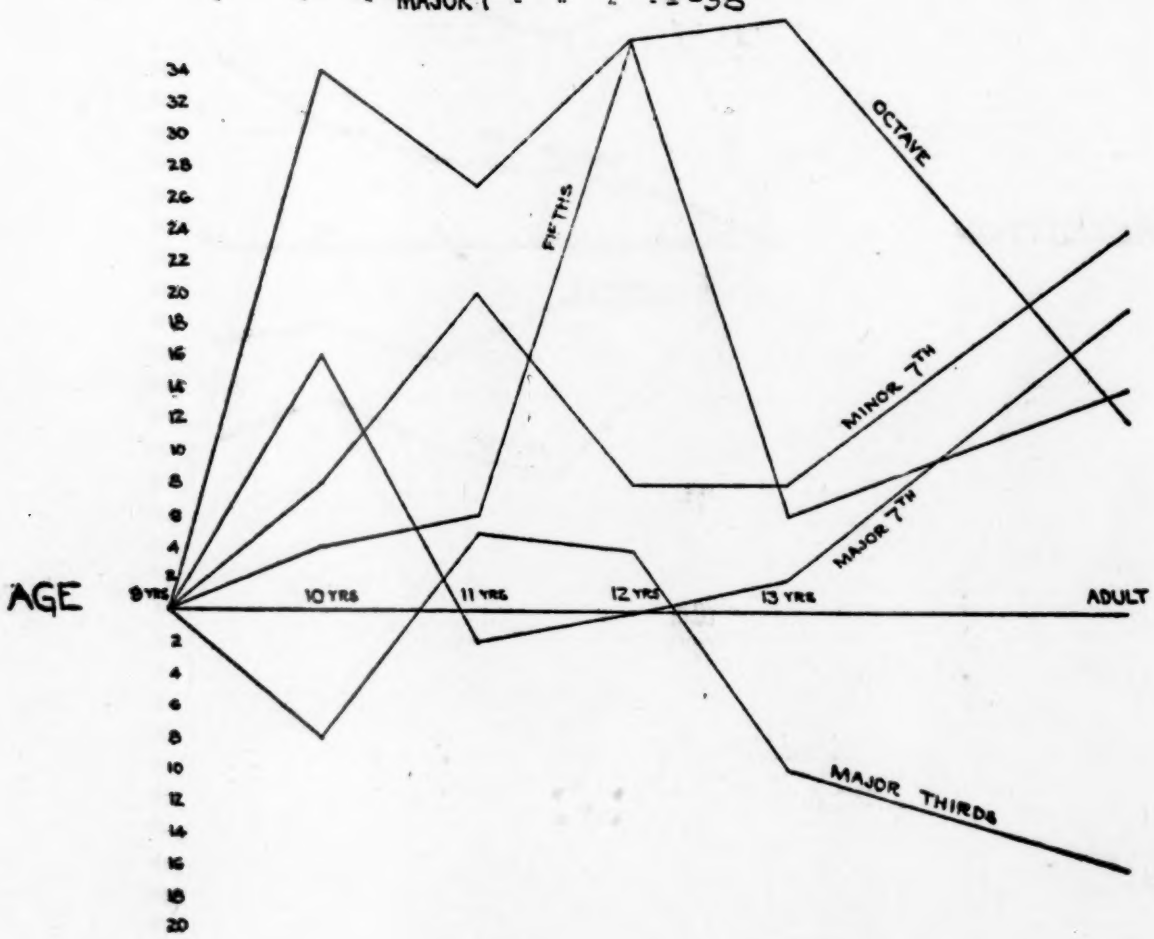


TABLE XXVII

ONTOGENETIC DEVELOPMENT OF INTERVAL PREFERENCES FROM RESULTS OF C.W. VALENTINE, GIRLS 9-14 YRS. AND WOMEN

INITIAL VALUE OF OCTAVE AT AGE OF 9 = +14
" " " FIFTH " " " " = +2
" " " THIRD " " " " = +52
" " " MINOR 7TH " " " = -44
" " " MAJOR 7TH " " " = -58